THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

ART. XVI.—*On an Isothermal Oceanic Chart, illustrating the Geographical Distribution of Marine animals;* by JAMES D. DANA.*

THE temperature of the waters is well known to be one of the most influential causes limiting the distribution of marine species of life. Before therefore we can make any intelligent comparison of the species of different regions, it is necessary to have some clear idea of the distribution of temperature in the surface waters of the several oceans: and, if we could add also, the results of observations at various depths beneath the surface, it would enable us still more perfectly to comprehend this subject. The surface temperature has of late years been quite extensively ascertained, and the lines of equal temperature may be drawn with considerable accuracy. But in the latter branch of thermometric investigation almost everything yet remains to be done: there are scattering observations, but none of a systematic character, followed through each season of the year.

The Map which we present in illustration of this subject presents a series of lines of equal surface temperature of the oceans. The lines are isocheimal lines, or more properly, *isocrymal* lines; and where they pass, each exhibits the mean temperature of the waters along its course for the coldest thirty consecutive days of the year. The line for 68° F., for example, passes through the ocean where 68° F., is the mean temperature for extreme cold weather. January is not always the coldest winter

* From the Author's Expl. Exped. Report on Crustacea, p. 1451.

month in this climate, neither is the winter the coldest season in all parts of the globe, especially near the equator. On this account, we do not restrict the lines to a given month, but make them more correctly the limit of the extreme cold for the year at the place.* Between the line of 74° north and 74° south of the equator, the waters do not fall for any one month below 74° F.; between 68° north and south, they do not fall below 68°.

There are several reasons why *isocrymal* are preferable to summer or *isotheral* lines. The cause which limits the distribution of species northward or southward from the equator is the cold of winter, rather than the heat of summer or even the mean temperature of the year. The mean temperature may be the same when the extremes are very widely different. When these extremes are little remote, the equable character of the seasons, and especially the mildness of the winter temperature, will favor the growth of species that would be altogether cut off by the cold winters where the extremes are more intense. On this account, lines of the greatest cold are highly important for a chart illustrating the geographical distributions of species, whether of plants or animals. At the same time, summer lines have their value: but this is true more particularly for species of the land, and fresh-water streams, and for sea-shore plants. When the summer of a continent is excessive in its warmth, as in North America, many species extend far from the tropics that would otherwise be confined within lower latitudes. But in the ocean, the extremest cold in the waters, even in the Polar regions wherever they are not solid ice, (and only in such places are marine species found,) is but a few degrees below 32° Fahrenheit. The whole range of temperature for a region is consequently small. The region which has 68° F. for its winter temperature, has about 80° for the hottest month of summer; and the line of 56° F. in the Atlantic, which has the latitudes of the state of New York, follows the same course nearly as the summer line of 70° F. In each of these cases the whole extent of the range is small, being twelve to fourteen degrees.†

In fresh-water streams, the waters, where not frozen, do not sink lower than the colder oceans, reaching at most but a few degrees below freezing. Yet the extremes are greater than for the ocean; for in the same latitudes which give for the ocean 56° and 70° F. as the limits, the land streams of America range in

* The word *isocrymal* here introduced is from the Greek ισος, *equal*, and κρυμος, *extreme cold*, and applies with sufficient precision to the lines for which it is used. These lines are not *isocheimal* lines, as these follow the *mean winter* temperature; and to use this term in the case before us, would be giving the word a signification which does not belong to it, and making confusion in the science.

† Moreover, the greatest range for all oceans is but 62° of Fahrenheit, the highest being 88°, and the lowest 26°; while the temperature of the atmosphere of the globe has a range exceeding 150°.

temperature between 30° and 80° F., and the summer warmth in such a case, may admit of the development of species that would otherwise be excluded from the region.

While then both isocrymal and isotheral lines are of importance on charts illustrating distribution over the continents, the former are pre-eminently important where the geography of marine species is to be studied.

The lines of greatest cold are preferable for marine species to those of summer heat, because of the fact also that the summer range of temperature for thirty degrees of latitude either side of the equator is exceedingly small, being but three to four degrees in the Atlantic, and six to eight degrees in the Pacific. The July isothermal for 80° F. passes near the parallel of 30°; and the extreme heat of the equatorial part of the Atlantic Ocean is rarely above 84°. The difficulty of dividing this space by convenient isothermals with so small a range is obvious.

It is also an objection to using the isotheres, that those towards the equator are much more irregular in course than the isocrymes. That of 80° for July, for example, which is given on our Map from Maury's Chart, has a very flexuous course. Moreover, the spaces between the isotheres fail to correspond as well with actual facts in geographical distribution. The courses of the cold water currents are less evident on such a chart, since the warm waters in summer to a great extent overlie the colder currents.

It is also to be noted that nothing would be gained by making the mean temperature for the year, instead of the extremes, the basis for laying down these lines, as will be inferred from the remarks already made, and from an examination of the chart itself.

The distribution of marine life is a subject of far greater simplicity than that of continental life. Besides the influence on the latter of summer temperature in connexion with that of the cold seasons, already alluded to, the following elements or conditions have to be considered:—the character of the climate, whether wet or dry;—of the surface of the region, whether sandy, fertile, marshy, etc.;—of the vegetation, whether that of dense forests, or open pasture-land, etc.;—of the level of the country, whether low, or elevated, etc. These and many other considerations come in, to influence the distribution of land species, and lead to a subdivision of the Regions into many subordinate Districts. In oceanic productions, depth and kind of bottom have an important bearing: but there is no occasion to consider the moisture or dryness of the climate; and the influence of the other peculiarities of region mentioned is much less potent than with continental life.

We would add here, that the data for the construction of this chart have been gathered, as regards the North Atlantic, from the isothermal chart of Lieutenant Maury, in which a vast amount of facts are registered, the result of great labor and study. For the

rest of the Atlantic and the other oceans we have employed the Meteorological volume of Captain Wilkes of the Exploring Expedition Reports, which embraces observations in all the oceans and valuable deductions therefrom; also, the records of other travellers, as Humboldt, Duperey of the Coquille, D'Urville of the Astrolabe, Kotzebue, Beechey, Fitzroy, Vaillant of the Bonite, Ross in his Antarctic Voyage, together with such isolated tables as have been met with in different Journals. The lines we have laid down, are not however, those of any chart previously constructed, for the reason stated, that they mark the positions where a given temperature is the mean of the coldest month (or coldest thirty consecutive days) of the year, instead of those where this temperature is the mean annual or monthly heat; and hence, the apparent discrepancies, which may be observed, on comparing it with isothermal charts.

The isocrymal lines adopted for the chart are those of 80°, 74°, 68°, 62°, 56°, 50°, 44°, and 35° of Fahrenheit. The temperatures diminish by 6°, excepting the last, which is 9° less than 44°.

In adopting these lines in preference to those of other degrees of temperature, we have been guided, in the first place, by the great fact, that the isocryme of 68° is the boundary line of the coral-reef seas, as explained by the author in his Report on Zoophytes.* Beyond this line either side of the equator, we have no species of true Madrepora, Astræa, Meandrina or Porites; below this line, these corals abound and form extensive reefs. This line is hence an important starting point in any map illustrating the geography of marine life. Passing beyond the regions of coral reefs, we leave behind large numbers of Mollusca and Radiata, and the boundary marks an abrupt transition in zoological geography.

The next line below that of 68° F., is that of 74° F. The corals of the Hawaiian Islands, and the Mollusca also to a considerable extent, differ somewhat strikingly from those of the Feejees. The species of Astræa and Meandrina are fewer, and those of Porites and Pocillopora more abundant, or at least constitute a much larger proportion of the reef material. These genera of corals include the hardier species; for where they occur in the equatorial regions they are found to experience the greatest range in the condition of purity of the waters, and also the longest exposures out of water. Their abundance at the Hawaiian Islands, as at Oahu, is hence a consequence of their hardier character, and not a mere region peculiarity independent of temperature. There are grounds, therefore, for drawing a line between the Hawaiian Islands and the Feejees; and as the temperature at

* In the author's Report on Geology, 66° F. is set down as the limiting temperature of Coral-reef Seas; this, however, is given as the *extreme* cold. 68° appears to be the *mean* of the coldest month, and is therefore here used.

the latter sinks to 74½° F. some parts of the year, 74° F. is taken as the limiting temperature. The Feejee seas are exceedingly prolific and varied in tropical species. The corals grow in great luxuriance, exceeding in extent and beauty anything elsewhere observed by the writer in the tropics. The ocean between 74° F., north of the equator, and 74° F. south, is therefore the proper tropical or torrid region of zoological life.

With respect to the line of 80° F., we are not satisfied that it is of much importance as regards the distribution of species. The range from the hottest waters of the ocean 88° to 74° F. is but fourteen degrees, and there are probably few species occurring within the region that demand a less range. Still, investigations hereafter made, may show that the hot waters limited by the isocryme of 80° include some peculiar species. At Sydney Island and Fakaafo, within this hot area, there appeared to be among corals a rather greater prevalence than usual of the genus Manopora, which as these are tender species, may perhaps show that the waters are less favorable for hardier corals than those of the Feejees, where the range of temperature is from 70° to 80° F.; but this would be a hasty conclusion, without more extended observations. The author was on these islands only for a few hours, and his collections were afterwards lost at the wreck of the Peacock, just as the vessel was terminating the voyage by entering the Columbia River.

It is unnecessary to remark particularly upon the fitness of the other isocrymals for the purposes of illustrating the geographical distribution of marine species, as this will become apparent from the explanations on the following pages.

The regions thus bounded require, for convenience of designation, separate names, and the following are therefore proposed. They constitute three larger groups: the *first*, the *Torrid* zone or *Coral-reef* seas, including all below the isocryme of 68° F.; the *second*, the *Temperate* zone of the oceans, or the surface between the isocrymes of 68° F. and 35° F.; the *third*, the *Frigid zone*, or the waters beyond the isocryme of 35° F.

Regions.	Isocrymal limits.
I. TORRID OR CORAL-REEF ZONE.	
1. Supertorrid,	80° F. to 80° F.
2. Torrid,	80° to 74°
3. Subtorrid,	74° to 68°
II. TEMPERATE ZONE.	
1. Warm Temperate,	68° to 62°
2. Temperate,	62° to 56°
3. Subtemperate,	56° to 50°
4. Cold Temperate,	50° to 44°
5. Subfrigid,	44° to 35°
III. FRIGID ZONE.	
1. Frigid,	35° to 26°

A ninth region—called the Polar—may be added, if it should be found that the distribution of species living in the Frigid zone requires it. There are organisms that occur in the ice and snow itself of the polar regions; but these should be classed with the animals of the continents; and the continental isotherms or isocrymes, rather than the oceanic, are required for elucidating their distribution.

It seems necessary to state here the authorities for some of the more important positions in these lines, and we therefore run over the observations, mentioning a few of most interest. There is less necessity for many particulars with reference to the North Atlantic, as our facts are mainly derived from Lieut. Maury's Chart, to which the author would refer his readers.

1. North Atlantic.—*Isocryme of* 74° F.—This isocryme passes near the reefs of Key West, and terminates at the northeast cape of Yucatan; it rises into a narrow flexure parallel with Florida along the Gulf Stream, and then continues on between the Little and Great Bahamas. To the eastward, near the African Coast, it has a flexure northward, arising from the hot waters along the coast of Guinea, which reach in a slight current upward towards the Cape Verde Islands. The line passes to the south of these islands, at which group, Fitzroy, in January of 1852, found the sea temperatures 71° and 72° F.

Isocryme of 68° F.—Cape Canaveral, in latitude 27° 30′, just north of the limit of coral reefs on the east coast of Florida, is the western termination of the line of 68°. The Gulf Stream occasions a bend in this line to 36° north, and the polar current, east of it, throws it southward again as far as 29° north. Westward it inclines much to the south, and terminates just south of Cape Verde, the eastern cape of Africa. Sabine found a temperature of 64° to 65° F. off Goree, below Cape Verde, January, 1822; and on February 9, 1822, he obtained 66½° near the Bissao shoals. These temperatures of the cold season contrast strikingly with those of the warm season. Even in May (1831), Beechey had a temperature of 86° off the mouth of Rio Grande, between the parallels of 11° and 12° north.

Isocryme of 62° F.—This isocryme leaves the American coast at Cape Hatteras, in latitude 35½° north, where a bend in the outline of the continent prevents the southward extension of the polar currents close along the shores. It passes near Madeira, and bends southward reaching Africa nearly in the latitude of the Canaries.

Isocrymes of 56° *and* 50° F.—Cape Hatteras, for a like reason, is the limit of the isocrymes of 56° and 50° as well as of 62°, there being no interval between them on the American coast. The line of 56° F. has a deep northward flexure between the meridians of 35° and 40° west, arising from the waters of the

Gulf Stream, which here (after a previous east and west course, occasioned by the Newfoundland Bank, and the Polar Current with its icebergs) bends again northeastward, besides continuing in part eastward. The Polar Current sometimes causes a narrow reversed flexure, just to the east of the Gulf Stream flexure. Towards Europe, the line bends southward, and passes to the southwest Cape of Portugal, Cape St. Vincent, or, perhaps to the north cape of the Straits of Gibraltar. Vaillant in the Bonite, found the sea-temperature at Cadiz in February, 49½° to 56° F. (9·7° to 13·4° C.), which would indicate that Cadiz, although so far south (and within sixty miles of Gibraltar), experiences at least as low a mean temperature as 56° F. for a month or more of the winter season. We have, however, drawn the line to Cape St. Vincent, which is in nearly the same latitude. Between Toulon and Cadiz, the temperature of the Mediterranean in February, according to Vaillant, was 55½° to 60½° F. (13·1° to 15·7° C.), and it is probable, therefore, that Gibraltar and the portion of the Mediterranean Sea east and north to Marseilles, fall within the *Temperate* Region, between the isocrymes of 56° and 62° F., while the portion beyond Sardinia and the coast by Algiers is in the *Warm Temperate* Region, between the isocrymes of 62° and 68° F.

The line of 50° F., through the middle of the ocean, has the latitude nearly of the southern cape at the entrance of the British Channel; but approaching Europe it bends downward to the coast of Portugal. The low temperature of 49½° observed by Vaillant at Cadiz would carry it almost to this port, if this were the mean sea-temperature of a month, instead of an extreme within the bay. The line appears to terminate near latitude 42°, or six degrees north of the isocryme of 56°. This allows for a diminution of a degree Fahrenheit of temperature for a degree of latitude. A temperature as low as 61° F. has been observed at several points within five degrees of this coast in *July*, and a temperature of 52° F., in February. Vigo Bay, just north of 42° north, lies with its entrance opening westward, well calculated to receive the colder waters from the north; and at this place, according to Mr. R. Mac Andrew, who made several dredgings with reference to the geographical distribution of species, the Mollusca have the character rather of those of the British Channel than of the Mediterranean.*

Isocryme of 44° F.—This line commences on the west, at Cape Cod, where there is a remarkable transition in species, and a natural boundary between the south and the north. The cold waters from the north and the ice of Newfoundland Banks, press the line close upon those of 50° and 56° F. But after getting beyond these influences, it rapidly rises to the north, owing to the

* Rep. Brit. Assoc., 1850, p. 264.

expansion of the Gulf Stream in that direction, and forms a large fold between Britain and Iceland; it then bends south again and curves around to the west coast of Ireland.

Isocryme of 35° F.—This line has a bend between Norway and Iceland like that of 44°, and from the same cause,—the influence of the Gulf Stream. But its exact position in this part has not been ascertained.

2. South Atlantic.—*Isocryme of* 74° F.—This line begins just south of Bahia, where Fitzroy found in August (the last winter month) a temperature of 74° to 75½° F. During the same month he had 75½° to 76½° F. at Pernambuco, five degrees to the north. Off Bahia, the temperature was two degrees warmer than near the coast, owing to the warm tropical current, which bends the isocryme south to latitude 17° and 18°, and the cold waters that come up the coast from the south. The line gradually rises northward, as it goes west, and passes the equator on the meridian of Greenwich. Sabine, in a route nearly straight from Ascension Island, in 8° south, to the African coast under the equator, obtained in June (not the *coldest* winter month) the temperatures 78°, 77°, 74°, 72·8°, 72·5°, 73°, the temperature thus diminishing on approaching the coast, although at the same time nearing the equator, and finally reaching it within a few miles. These observations in June show that the isocryme of 74° F. passes north of the equator. The temperatures mentioned in Maury's Chart afford the same conclusion, and lead to its position as laid down.

Isocryme of 68° F.—On October 23d to 25th, 1834, Mr. D. J. Browne, on board the U. S. Ship Erie, found the temperature of the sea on entering the harbor of Rio Janeiro, 67½° to 68½° F. Fitzroy on July 6, left the harbor with the sea temperature 70½° F. Beechey, in August, 1825, obtained the temperature 68·16° to 69·66° F. off the harbor. The isocryme of 68° F. commences therefore near Rio, not far south of this harbor. Eastward of the harbor, the temperature increases two to four degrees. In July, Fitzroy carried a temperature above 68° as far south as 33° 16′ south, longitude 50° 10′ west, the water giving at this time 68½ to 69½° F. Beechey in August obtained 68° F. in 31° south, 46° west. The isocryme of 68° F. thus bends far south, reaching at least the parallel of 30°. It takes a course nearly parallel with the line of 74° F., as different observations show, and passing just south of St. Helena, reaches the African coast, near latitude 7° south. Fitzroy, on July 10 (mid-winter), had a sea-temperature of 68½° near St. Helena; and Vaillant, in the Bonite, in September found the sea-temperature 68·7° to 69·26° F.

Isocrymes of 56° *and* 50° F.—These two isocrymes leave the American coast rather nearly together. The former commences just north of the entrance of the La Plata. Fitzroy, in July 23

to 31, 1832, found the sea-temperature at Montevideo 56° to 58° F., and in August, 57° to 54½° F. These observations would lead to 56° F. as nearly the mean of the coldest month. The temperature 56 F. was also observed in 35° south, 53° west, and at 36° south, 56° 36′ west. But on July 10 and 13, 1833, at Montevideo, the sea-temperature was 46½° to 47½°, a degree of cold which, although only occasional, throws the line of 56° F. to the north of this place. The temperature near the land is several degrees of Fahrenheit lower than at sea three to eight degrees distant. East of the mouth of the La Plata, near longitude 30° west, Beechey, in July, 1828, found the temperature of the sea 61·86° F. So in April 23 to 29, Vaillant obtained the temperature 59·5° to 61·25° F. at Montevideo, while in 35° 5′ south, 49° 23′ west, on April 14, it was 66·2° F., and farther south, in 37° 42′ south, 53° 28′ west, April 30, it was 64·4° F.; and in 39° 19′ south, 54° 32′ west, on May 1, it was 57⅜° F.; but a little to the westward, on May 2, in 40° 30′ south, 56° 54′ west, the temperature was 48° F., an abrupt transition to the colder shore waters. Beechey, in 39° 31′ south, 45° 13′ west, on August 28 (last of winter), found the temperature 57·25° F., and on the 29th, in 40° 27′ south, 45° 46′ west, it was 54·20°; while on the next day, in 42° 27′ south, 45° 11′ west, the temperature fell to 47·83° F. These and other observations serve to fix the position of the isocryme of 56° F. It approaches the African coast, in 32° south, but bends upward, owing to cold waters near the land. On August 20, Vaillant, in 33° 43′ south, 15° 51′ east, found the temperature 56° F.; while on the 22d, in the same latitude, and 14° 51′ east (or one degree farther to the westward), the temperature was 57·74° F., being nearly two degrees warmer. At Cape Town, in June (latitude 34°), Fitzroy found 55° to 61° F., while on August 16, farther south, in 35° 4′ south, and 15° 40′ west, one hundred and fifty miles from the Cape, Vaillant found the temperature 59·26° F. The high temperature of the last is due to the warm waters that come from the Indian Ocean, and which afford 61° to 64° F. in August, off the south extremity of Africa, west of the meridian of Cape Town.

The isocryme of 50° F. leaves the American coast just south of the La Plata; after bending southwardly to the parallel of 41°, it passes east nearly parallel with the line of 56° F. It does not reach the African coast.

Isocrymes of 44° *and* 35° F.—Fitzroy in August (the last winter month) of 1833, found the sea-temperature at Rio Negro (latitude 41° south) 48½° to 50° F. But during the voyage from the La Plata to Rio Negro, a few days before, a temperature of 44½° to 46° was met with; this was in the same month in which the low temperature mentioned above was found at Montevideo. The bend in the course north of the entrance to

the La Plata, is to some extent, a limit between the warmer waters of the north, and the colder waters from the south; not an impassible limit, but one which is marked often by a more abrupt transition than occurs elsewhere along this part of the coast. The water was generally three or four degrees colder at Montevideo, than at Maldonado, the latter port being hardly sheltered from the influence of the tropical waters, while Montevideo is wholly so. The exact point where the line of 44° F. reaches the coast is somewhat uncertain; yet the fact of its being south of Rio Negro is obvious. After leaving the coast, it passes north of 47½° south, in longitude 53° west, where Beechey, in July, 1828, found the sea-temperature 40·70° F.

The line of 35° F. through the middle of the South Atlantic, follows nearly the parallel of 50°; but towards South America it bends southward and passes south of the Falklands and Fuegia. At the Falklands, Captain Ross, in 1842, found the mean temperature of the sea for July, 38·73°, and for August, 38·10°; while in the middle of the Atlantic, on March 24, latitude 52° 31′ south, and longitude 8° 8′ east, the temperature was down to 34·3° F., and in 50° 18′ south, 7° 15′ east, it was 37° F.; March 20, in 54° 7′ south on the meridian of Greenwich, it was 33·4° F. The month of March would not give the coldest temperature.

The temperature of the sea along the south coast of Fuegia sinks almost to 35°, if not quite, and the line of 35° therfore runs very near Cape Horn, if not actually touching upon Fuegia.

North Pacific Ocean.—*Isocryme of* 80° F.—The waters of the Atlantic in the warmest regions, sink below 80° F. in the colder season, and there is therefore no proper Supertorrid Region in that ocean. In the Gulf of Mexico, where the heat rises at times to 85° F., it sinks in other seasons to 74° and in some parts, even to 72° F.; and along the Thermal equator across the ocean, the temperature is in some portions of the year 78°, and in many places 74°.

But in the Pacific, where the temperature of the waters rises in some places to 88° F., there is a small region in which through all seasons, the heat is never below 80°. It is a narrow area, extending from 165° east to 148° west, and from 7½° north to 11° south. In going from the Feejees in August, and crossing between the meridians of 170° west and 180°, the temperature of the waters, according to Captain Wilkes, increased from 79° to 84° F., the last temperature being met with in latitude 5° south, longitude 175° west and from this, going northward, there was a slow decrease of temperature. The Ship Relief, of the Expedition, in October, found nearly the same temperature (83½°) in the same latitude and longitude 177° west.* But the Peacock, in

* See, for these facts, Captain Wilkes's Report on the Meteorology of the Expedition.

January and February (*summer* months), found the sea-temperature 85° to 88° F., near Fakaafo, in latitude 10° south, and longitude 171° west. In latitude 5° south and the same longitude, on the 16th of January, the temperature was 84°; in 3° south, January 10th, it was 83° F.; on March 26th, in 5° south, and longitude 175° east, the temperature was 86° F.; on April 10th, in the same longitude, under the equator, at the Kingsmills, the temperature was 83½° F.; on May 2d, at 5° north, longitude 174° east, 83½° F.; May 5th, latitude 10°, longitude 169° east, 82° F. The fact that the region of greatest heat in the Middle Pacific is south of the equator, as it has been laid down by different authors, is thus evident; the limits of a circumscribed region of hot waters in this part of the Pacific, were first drawn out by Captain Wilkes.

Another Supertorrid region may exist in the Indian Ocean, about its northwestern portion; but we have not sufficient information for laying down its limits.

Isocryme of 74° F.—At San Blas, on the Coast of Mexico, Beechey found the mean temperature of the sea for December, 1827, 74·63° F.; for January, 73·69° F.; for February, 72·40° F. The line of 74° F. commences therefore a degree or two south of San Blas. In the winter of 1827 on January 16 to 18, the temperature of 74·3° to 74·6° F. was found by Beechey, in 16° 4′ to 16° 15′ north, 132° 40′ to 135° west; and farther west, in the same latitude, longitude 141° 58′ west, the temperature was 74·83° F. West of the Sandwich Islands, near the parallel of 20° north, the temperature rises five degrees in passing from the meridian of 165° west to 150° east, and the isocryme of 74° F., consequently trends somewhat to the north, over this part of the ocean. Between the meridians of 130° and 140° east, the temperature of the sea is quite uniform, indicating no northward flexure; and west of 130° east, nearing China, there is a rapid decrease of temperature, bending the line far south. Vaillant of the Bonite, found the sea of Cochin China, in latitude 12° 16′ north, 109° 28′ east, to have the temperature 74·12° F.; and even at Singapore, almost under the equator, the temperature on February 17 to 21, was 77·54° to 79·34° F. The isocryme of 74° F. terminates therefore upon the southeastern coast of Cochin China.

Isocryme of 68°—Off the Gulf of California, in 25° north, 117° west, Beechey obtained for the temperatue of the sea on December 13, 65° F.; on December 15, in 23° 28′ north (same latitude with the extremity of the peninsula of California), 115° west, a temperature of 69·41° F. The line of 68° will pass from the extremity of this peninsula, the temperature of the coast below, as it is shut off mostly from the more northern or cold waters, being much warmer. The temperature 69·41° in the middle of De-

cember, is probably two and a half degrees above the cold of the coldest month, judging from the relative temperatures of the latter half of December and the mouth of February at San Blas. Leaving California, the isocryme of 68° will therfore bend a little southerly to 22½°, in longitude 115° west. In 23° 56′ north, 128° 33′ west, Beechey, on January 11, found the temperature of the sea 67·83° F. The line of 68° passes north of the Sandwich Islands. The mean temperature of the sea at Oahu in February, 1827, was 69·69° F.

Near China, this isocryme is bent far south. At Macao, in winter, Vaillant found the sea-temperature, on January 4, 59° F.; on January 5 to 10, 52·7° to 50° F.; January 11, 12, 49·87° to 48·74° F.; January 13 to 16, 50·9° to 52·16° F.; and at Touranne in Cochin China, on February 6 to 24, the sea-temperature was 68° to 68½° F.; in 16° 22′ north, 108° 11′ east, on January 24, it was 67°; in 12° 16′ north, 109° 28′ east, it was 74·12° F. The very low Macao temperature is that of the surface of the Bay itself, due to the cold of the land, and not probably, as the other observations show, of the sea outside.

The line, before passing south, bends northward to the southeast shore of Niphon, which is far warmer than the southeast coast, along Kiusiu. In the Report of the Morrison's visit to Jeddo (Chinese Repository for 1837), a coral bottom is spoken of, as having been encountered in the harbor of Jeddo. According to Siebold (Crust. Faun. Japon., p. ix.), the mean winter temperature (air) of Jeddo is 57° F.; while that of Nagasaki, although farther south, is 44° F.

Isocryme of 62° F.—On January 8, 1827, Beechey found in 29° 42′ north, 126° 37′ west, the temperature 62·75° F.; while on the preceding day, 32° 42′ north, 125° 43′ west, the sea-temperature was 60·5° F. Again, on December 11, in 29° north, 120° west, the temperature was 62·58° F.

Isocryme of 56° F.—At Monterey, on January 1 to 5, the sea-temperature according to Beechey was 56°; but the mean temperature of the sea for November 1 to 17, was 54·91°. In the Yellow Sea, the January temperature is 50° to 56° F., and the line of 56° begins south of Chusan.

Isocryme of 50° F.—At San Francisco, from November 18 to December 5, 1826, Beechey found the mean sea-temperature to be 51·14° F., and off Monterey, in longitude 123° west, the temperature was 50·75° F., on December 6. But in December of 1826, the mean sea-temperature at San Francisco was 54·78° F.; and for November, 60·16° F. The line of 50° F. (mean of the coldest thirty consecutive days), probably leaves the coast at Cape Mendocino.

Isocrymes of 44° *and* 35° F.—Captain Wilkes found the temperature off the mouth of the Columbia River, through ten de-

grees of longitude, 48° to 49° F., during the last of April, 1841. The isocryme of 44° would probably reach the coast not far north of this place. The temperature on October 21, in the same latitude, but farther west, 147° west, was 52·08° F. On October 16, in 50° north, 169° west, the temperature was 44·91° F. According to some oceanic temperatures for the North Pacific, obtained from Lieutenant Maury, the sea-temperature off northern Niphon, in 41° north and 142½° east, was 44° F., in March, showing the influence of the cold Polar current; and in 42° north, and 149½° east, it was 43° F. The line of 44° hence bends southward as far as latitude 40° north, on the Japan coast.

Again in March, in 43° 50′ north, 151° east, the sea-temperature, was 41° F.; in 44° 50′ north, 152° 10′ east, 39° F.; in 46° 20′ north, 156° east, 33° F.; in 49° north, 157° east, 33° F.; and at the same time, west of Kamschatka, in 55° north, 153° east, 38° F.; in 55° 50′ north, 153° west, 38° F. The line of 35° consequently makes a deep bend, nearly to 45° north, along the Kurile Islands.

South Pacific.—*Isocrymes of* 74°, 68°, *and* 62° F.—The temperature of the sea at Guayaquil, on August 3d, was found by Vaillant, to be, in the river, from 70½° to 73½° F., and at the Puna anchorage, August 5 to 12, 74·7° to 75·2° F. But off the coast, August 15, in 2° 22′ south, 81° 42′ west, the temperature was 69·8° F.; and the next day, in 1° 25′ south, 84° 12′ west, it was 70° F.; on the 17th, 1° south, 87° 42′ west, it was 71·28° F.; and on the 14th, nearer the shore of Guayaquil, in 3° 18′ south, 80° 28′ west, it was 78° F. Again, at Payta, one hundred miles south of Guayaquil, in 5° south, the sea-temperature was found by Vaillant, July 26 to 31, to be 60·8° to 61½° F. The isocryme of 74° F., consequently leaves the coast just north of the bay of Guayaquil, while those of 68° and 62° F., both commence between Guayaquil and Payta. Payta is situated so far out on the western cape of South America that it receives the cold waters of the south, while Guayaquil is beyond Cape Blanco, and protected by it from a southern current. At the Gallapagos, Fitzroy found the temperature as low as 58½° F. on the 29th of September, and the mean for the day was 62°. The average for September was, however, nearer 66°. The Gallapagos appear therefore, to lie in the Warm Temperate Region, between the isocrymes of 62° and 68° F. Fitzroy, in going from Callao to the Gallapagos, early in September, left a sea-temperature of 57° F. at Callao, passed 62° F. in 9° 58′ north, and 79° 42′ west, and on the 15th, found 68½° F. off Barrington Island, one of the Gallapagos.

In the warm season, the cold waters about the Gallapagos have narrow limits; Beechey found a sea-temperature of 83·58° on the

30th of March, 1827, just south of the equator, in 100° west. But in October, Fitzroy, going westward and southward from the Gallapagos, found a sea-temperature of 66° F. at the same place; and in a nearly straight course from this point to 10° south, 120° west, found the sea-temperatures successively, 68°, 70°, 70½° 72½°, 73½°, 74°; and beyond this, 75½°, 76½°, 77½° F., the last on November 8, in 14° 24′ south, 136° 51′ west. These observations give a wide sweep to the cold waters of the colder seasons, and throw the isocrymes of 74° and 68° F., far west of the Gallapagos. Captain Wilkes, in passing directly west from Callao, found a temperature of 68° F., in longitude 85° west; 70° F., in 95° west; and 74° F., in 102° to 108° west. These and other observations lead to the positions of the isocrymes of 74°, 68°, and 62°, given on the Chart. The line of 74° passes close by Tahiti and Tongatabu, and crossing New Caledonia, reaches Australia in latitude 25° S.

In mid-ocean there is a bend in all the southern isocrymes.*

Isocrymes of 56° and 50° F.—The temperature at Callao, in July, averages 58½° or 59° F. At Iquique, near 20° south, Fitzroy had 58° to 60° F., on July 14, 1835; and off Copiapo, in the same month, 56½° F. At Valparaiso, Captain Wilkes found a sea-temperature of 52½° F., in May; and Fitzroy, in September, occasionally obtained 48° F., but generally 52° to 53°. Off Chiloe, Fitzroy found the temperature 48° to 51½° in July.

Indian Ocean.—*Isocrymes of 74° and 68° F.*—Off the south extremity of Madagascar, in 27° 33′ south, 47° 17′ east, on August 4th, Vaillant found the temperature 69·26° F.; and in 29° 34′ south, 46° 46′ east, the temperature of 67·84° F.; off South Africa, August 12, in 34° 42′ south, 27° 25′ east, the temperature 63·5° F.; on August 14, in 35° 41′ south, 22° 34′ east, a temperature of 63·3° F.; while off Cape Town, two hundred miles to the west, the temperature was 50° to 54° F.

In the above review, we have mentioned only a few of the observations which have been used in laying down the lines, having selected those which bear directly on some positions of special interest, as regards geographical distribution.

The Chart also contains the *heat-equator*,—a line drawn through the positions of greatest heat over the oceans. It is a shifting line, varying with the seasons, and hence, there is some difficulty in fixing upon a course for it. We have followed mainly the Chart of Berghaus. But we have found it necessary to give it a much more northern latitude in the western Pacific, and also a flexure in the western Atlantic, both due to the currents from the south that flow up the southern continents.

Vaillant passing from Guayaquil to the Sandwich Islands, found the temperature, after passing the equator, slowly increase,

* See Observations by W. C. Cunningham, Am. J. Sci., [2] xv, 66.

from 76° F., August 19, in 2° 39′ north, 91° 58′ west (of Greenwich), to 81·9° F., in August 31, 11° 15′ north, 107° 3′ west, after which it was not above 80° F. The same place in the ocean which gave Vaillant 76° F., in August, afforded Fitzroy (4° north, 96° west), on March 26 (when the sun had long been far north), 82½° F. This fact shows the variations of temperature that take place with the change of season.

(To be continued.)

ART. XVII.—*Contributions to Mineralogy;* by Dr. F. A. GENTH of Philadelphia.

(Concluded from p. 86.)

5. *Owenite*, a new mineral.—I found this mineral in the metamorphic rocks on both sides of the Potomac River near Harpers Ferry, associated with quartz and sometimes with impressions of carbonate of magnesia.

Massive, aggregate of minute scales; cleavage distinct in one direction; H. =2·5; Sp. gr. =3·197 (at 20° C.); color olive-green; streak paler; lustre pearly; fracture subconchoidal; very tough; powder greasy to the touch; odor argillaceous.

BB. fuses easily =3, and gives an iron black magnetic globule; with borax gives the reactions of iron, and with soda in the oxydating flame shows the presence of a trace of manganese. Yields water in the matrass. Dissolves readily in dilute hydrochloric acid.

It was analyzed under my immediate supervision by Mr. Peter Keyser, who obtained the following results.

I. 1·8920 grammes ignited for about forty-five minutes at a bright red heat in a well covered platinum crucible, lost 0·2050 grs.

II. 1·1542 grs. treated in the same manner, lost 0·1195 grs.

It is possible, that these determinations of water are a little too low, because a small quantity of iron was found to have oxydized higher on heating.

III. 2·0770 grs. were dissolved in hydrochloric acid. The silicic acid gelatinized on evaporation; it was evaporated to dryness, the dry mass moistened with hydrochloric acid, diluted with water and filtered after it had completely settled. The silicic acid weighed 0·4798 grs.

The filtrate was oxydized by nitric acid, precipitated by ammonia, redissolved in acetic acid and evaporated in a water-bath, again moistened with water and this often repeated, until all the acetates of alumina and iron were thus decomposed. Both were filtered, and alumina separated from the sesquioxyd of iron by caustic potash in the usual manner. From the acidulated potash solution the alumina was precipitated by sulphid of ammonium; it gave 0·3226 grammes.

The sesquioxyd of iron was redissolved in hydrochloric acid and precipitated by ammonia; it weighed 1·0865 grs.

From the soluble acetates, to which chlorid of ammonium had been added, the lime was precipitated as oxalate, which yielded 0·0106 grs. carbonate of lime.

The filtrate was evaporated to dryness and the magnesia separated from the alkalies by oxyd of mercury; the magnesia was redissolved and precipitated with all the requisite precautions as phosphate of magnesia and ammonia, which gave 0·0670 grs. pyrophosphate of magnesia.

The mixed chlorids of sodium and potassium weighed 0·0185 grs. and the platinum 0·0033 grs.

IV. 1·3668 grs. dissolved and the silica separated as in III, gave 0·3187 grs. silicic acid. From the filtrate, oxydized by nitric acid, both sesquioxyd of iron and alumina were precipitated by ammonia, and the alumina separated from sesquioxyd of iron as above; it weighed 0·2138 grs. The sesquioxyd of iron redissolved and precipitated by ammonia was 0·7148 grs. The filtrate from the sesquioxyd of iron was added to the liquid containing lime and magnesia, and after being concentrated by evaporation was precipitated by oxalate of ammonia. The oxalate gave 0·0100 grs. carbonate of lime.

The magnesia was precipitated from the filtrate by phosphate of soda, and gave 0·495 grs. of pyrophosphate of magnesia.

V. 1·2898 grs. were dissolved in a flask, from which all the air had been displaced by carbonic acid, and the apparatus cooled, while a constant current of carbonic acid passed through it in order to prevent an oxydation of the oxyd into sesquioxyd of iron; then an excess of terchlorid of gold and sodium was added through a tube; the apparatus filled with carbonic acid was allowed to stand twenty-four hours and then filtered. The reduced gold weighed 0·4056 grs.

These results give the composition of Owenite as follows:

	I, III and V.	II, IV and V.	Mean.			
SiO_3	23·10	23·32	23·21	contains oxygen =	12·05	
Fe_2O_3	13·90	13·88	13·89	"	4·16	11·45
Al_2O_3	15·53	15·64	15·59	"	7·29	
FeO	34·58	34·58	34·58	"	7·68	8·39
MnO	*trace*			"		
MgO	1·16	1·37	1·26	"	0·49	
CaO	0·29	0·43	0·36	"	0·10	
NaO	0·41	0·41	0·41	"	0·11	
KO	0·08	0·08	0·08	"	0·01	
HO	10·84	10·35	10·59	"	9.42	
	99·89	100·06				

The ratio of oxygen of $RO : R_2O_3 : SiO_3 : HO$ is,

8·39 : 11·45 : 12·05 : 9·42 or very near

1 : 1·5 : 1·5 : 1

corresponding with the formula $2(3RO, SiO_3)+(3R_2O_3, SiO_3)+6HO$.

Owenite is closely allied to some other minerals, viz., Aphrosiderite and Thuringite, and they all resemble each other so very much that their difference can be detected only by a chemical examination. Aphrosiderite is a mineral not generally known, found at several localities in Nassau, and distinguished from earthy chlorite by Fridolin Sandberger, who gave an analysis of it in his "Uebersicht der geologischen Verhältnisse des Herzogthums Nassau," but without calculating its formula. He found that it contains:

SiO_3	= 26·45	which contains oxygen	13·73	
Al_2O_3	= 21·25	"	9·93	
FeO	= 44·24	"	9·82	10·23
MgO	= 1·06	"	0·41	
HO	= 7·74	"	6·88	
	100·74			

The ratio of oxygen of $RO : Al_2O_3 : SiO_3 : HO$ is

$$10·23 : 9·93 : 13·73 : 6·88 \text{ or very near}$$
$$1·5 : 1·5 : 2 : 1$$

which corresponds with the formula $3(3RO, SiO_3)+(3Al_2O_3, SiO_3)+6HO$.

Breithaupt's thuringite according to an analysis of Rammelsberg, is $3(3RO, SiO_3)+(2Fe_2O_3, SiO_3)+9HO$.

The relation of these three minerals will be seen from the following formulæ:

Owenite $= 2(3RO, SiO_3)+(3R_2O_3, SiO_3)+6HO$;
Aphrosiderite $= 3(3RO, SiO_3)+(3Al_2O_3, SiO_3)+6HO$;
Thuringite $= 3(3RO, SiO_3)+(2Fe_2O_3, SiO_3)+9HO$.

This mineral is named in honor of Dr. David Dale Owen, U. S. Geologist.

6. *Kämmererite—Emerald Nickel.*—A year ago, before I had received my foreign journals, I published two analyses of Kämmererite, and finding these different from Kämmererite and Rhodochrome, I proposed for it the name "Rhodophyllite." On being informed that Dr. J. L. Smith was about making an investigation of the same mineral, I wrote him that the conclusion to which I had arrived, after comparing the results of my analyses and those of Mr. Hermann, was, that Kämmererite and my Rhodophyllite were the same mineral, and requested him to mention it in his paper. This ought to have been sufficient. Notwithstanding, an indirect criticism of my analyses by Mr. Garrett, based upon *one* analysis, made by him, has since appeared in the May number of the Journal of Science. Mr. Garrett condemns

my analyses by saying, that Mr. Hermann's, with which mine agree a great deal better than with his, are "unquestionably erroneous." If Mr. Garrett had taken the trouble to give the details of his results, it would then be much easier to find out where the blunder lies. Unfortunately he has not done so, and therefore I am compelled to believe that I am right, since I know that all pains were taken to analyze most carefully a pure mineral, and my analyses agree well with each other.

With reference to his article on emerald-nickel, it suffices to say, that I have described the mineral in 1851 under the name Nickelgymnite.* It is a variety of gymnite in which a variable quantity of magnesia is substituted by nickel. and when pure, it does not contain a trace of carbonic acid. Mr. Garrett would not have arrived at such a scientific formula if he had been more careful in selecting his material. The same is to be said of Mr. Hermann's Pennine, which is a mixture of Kämmererite, Dolomite, Nickelgymnite, etc.

ART. XVIII.—*Hassler's Experiments on the Expansion of Water at various temperatures;* by J. H. ALEXANDER, Esq.

THE late Mr. Hassler enjoyed, during his life-time, a high reputation: but one founded, it would appear, at least in this country, more upon the prestige of his manifest and presumed moral and intellectual faculties, than upon any just knowledge or estimate of his special achievements in Science or Art. It is true that these faculties were both large and well-defined; and they had a scope for their exhibition, sometimes, more favorable to the interest of the spectator than the ease and comfort of the actor. He was undaunted, diligent, patient, self-reliant; no man feared an adversary less, or loved friends more; sympathetic, too, and (for which credit was not generally given him) tender-hearted; still his stern self-command enabled him for many years to fold his robe with a certain grace over wounds of soul and body, so deep and sore as to have put out of the heads of many others, who yet think themselves strong men, all idea of the dignity of sorrow. Intellectually, also, Nature had been bountiful to him, and under his finely shaped cranium had placed a net-work of brain, active in perception, and of firm retention. All the organism for a Geometer was there; and wit and humor, too, with a spice of dogmatism, that like carbonic acid in certain wines (itself an irrespirable gas) only served to make them more racy and *montants*. Unfamiliar people were apt to suppose that

* Keller-Tiedemann's Nordamerikanischer Monatsbericht, Nov., 1851.

this free acidity predominated, normally; but the fact was, that his dogmatism arose out of his disgust at all pretence, and it was always manifested in proportion to the difference between the reality and the pretension in any person or thing that exhibited the latter. He was essentially a man of truth: assumption of any kind disgusted him; while to assumption without a basis (or what is commonly called humbug) he was never merciful, but visited it with all the weight of logic and the sharpness of sarcasm. Those who knew him, knew that he could be both heavy and sharp.

But to draw traits of character was by no means the object of this memoir; what has been said, has slipped from my pen spontaneously. It is true, that honored by the intimacy of Mr. Hassler, and even bound by a sort of half promise (for in the mathematical probabilities of life, there was every chance of my being long his survivor) I should years since, had the means been at my disposal, have endeavored to do justice to his memory by an account of the events he had mixed in, of the services he had rendered towards the stabilitation and diffusion of knowledge, and of the methods which he partly originated, and partly combined, for divers researches of science.

But the present notice of one of these methods, and of its successful employment in the determination of a set of physical constants, is owing to no such editorial impulse. The fact is, that having occasion, in behalf of professional investigations in which I was concerned, to wish for a better tabulated statement of the specific gravity of water at various temperatures than any of those which were accessible to me, it came into my head to examine, reduce, and compare the quite extensive series of observations on this point which Mr. Hassler had made, the apparatus for which I had frequently seen, and the making out of the final results of which had been postponed as I knew, until a more favorable opportunity for their augmentation and extension. These observations, to the number of two hundred and more, were published in 1832 in a Congressional document,* being a report to the Treasury Department on the Comparison of Weights and Measures, where also the description and drawings of the peculiar apparatus is given. As it is no wise necessary to repeat here what is in print elsewhere, this reference will be sufficient. Only these particulars may be noted, viz: 1st, that the quantity of water operated upon, upwards of 30 avoirdupois pounds, was such as vastly to magnify the differences, and reduce the errors of observation; 2nd, that the extent of observation, going as far as the variation of temperature in a whole year, and always allowing the temperatures to settle themselves by their natural tendency in a

* Twenty-second Congress, 1st Sess., H. R., No. 299.

room set apart for the purpose, instead of being forced, unstable and therefore doubtful, as in all cases of production of artificial transient temperatures, is such as to afford a more than usual check upon the accuracy of any part of it, and a more than usual confidence in the equilibrium of the temperatures averred.

In this method of observation, it follows that the actual temperatures and the corresponding weights succeed one another irregularly. The first thing to be done, then, was to group the resulting weights, degree by degree, and thus prepare them for their arithmetical means. Their preparation resulted in a synoptical table, in which the average weights corresponding to fractions of almost every degree of Fahrenheit between 35° and 86° found a place. This synopsis was then converted into another, where the temperature was given in whole degrees, and the weights corresponding found by taking proportional parts of the actual weights observed for the said fractions. Then, in order to cover the irregularities of result existing as between degree and degree, and to ensure a sufficient generalization, these last ascertained weights were tabulated from five to five degrees, commencing with 40°, which is so near the density of maximum density as to allow of being assumed for it. In fact, the actual difference of weight observed between 39°·4 and 40°·4 is only 2·4 grains on a weight of nearly 228000 grains, or somewhat more than the $\frac{1}{100000}$ part.

The differences of the weights in this last tabulation, divided by 5, and thus reduced to a rate per degree for every five degrees, presented a quite harmonious diverging series; the second differences were nearly constant, and the *plus* and *minus* third differences almost exactly balanced. The mean of these second differences was then taken as a constant; and a new series constructed, which starting from the actual weight found at 40° F., was duly applied at every five degrees to give a new set of *calculated* weights for the respective epochs of temperature. How nearly the two sets of weights agree, will be seen in the following table:

Temperature.	Weights calculated.	Weights observed.	Proportional Differences.
40°	227843·3	227843·3	0· –
45°	837·3	837·3	0· –
50°	811·3	815·4	−0·000014
55°	765·3	766·–	−0·000003
60°	699·3	695·3	+0·000018
65°	613·3	604·3	+0·000040
70°	507·3	501·8	+0·000024
75°	381·3	371·5	+0·000043
80°	235·3	230·5	+0·000021
85°	227069·3	227076·5	−0·000032

What remained, then, was to convert the said calculated weights into decimal parts of unity taken as the maximum density of

water and so occurring as beforesaid at 40° F. Finally, the densities were interpolated from degree to degree between these epochs, according to a method which I have given in a former volume of this Journal.

The final results are given in the following

Table of the Specific Gravities of Water at successive Temperatures of Fahrenheit's Thermometer.

Temp. F.	Specific Gravity.	Temp. F.	Specific Gravity.
40°	1·	63	0·9991523
41	0·9999997	64	0·9990732
42	0·9999978	65	0·9989905
43	0·9999948	66	0·9989043
44	0·9999860	67	0·9988147
45	0·9999737	68	0·9987217
46	0·9999579	69	0·9986252
47	0·9999385	70	0·9985253
48	0·9999157	71	0·9984219
49	0·9998893	72	0·9983149
50	0·9998595	73	0·9982043
51	0·9998262	74	0·9980901
52	0·9997894	75	0·9979723
53	0·9997491	76	0·9978510
54	0·9997052	77	0·9977263
55	0·9996577	78	0·9975981
56	0·9996067	79	0·9974665
57	0·9995522	80	0·9973315
58	0·9994942	81	0·9971929
59	0·9994328	82	0·9970507
60	0·9993680	83	0·9969049
61	0·9992997	84	0·9967555
62	0·9992278	85	0·9966025

Empirical Formula :—

t° = observed temperature ∴

$$\text{Sp. Gr. at } t^\circ = (69 + 35{\cdot}15 . \overline{t^\circ - 42^\circ}) \frac{t^\circ - 42^\circ}{2}.$$

Art. XIX.—*Biography of Berzelius;* by Prof. H. Rose, of Berlin.

(Continued from p. 15.)

Previous to Berzelius, Dalton, in his new System of Chemical Philosophy, had attempted to express numerically the relative quantities in which bodies generally combine, and by this means, as he regarded bodies as consisting of atoms, he sought to establish as it were the relative weights of the ultimate atoms. Thus originated the doctrine of the so-called atomic weights.

To Dalton, therefore, belongs the great merit of having given the correct idea of that which is now universally called atom in chemistry. Richter had previously employed in a similar sense the name relative mass (massentheil), in order to express the different quantities of acid and base which combine together forming salts; his idea however, was not so material as that of Dalton, and this character was necessary to give it that perfect clearness, which was indispensable, if a theory was to be founded upon it. The long and obstinate opposition which was made by German philosophers to the idea of atoms as employed in chemistry, and the war waged with all the weapons of logical acumen against the atomic view of the composition of bodies, for a long time rather obstructed than favored the advancement and spread of the exact sciences, especially that of chemistry. Now that the atomic theory is adopted by all, the use of the word atom is allowed by all in order to explain the facts with ease and simplicity.

Dalton assumed that simple substances combined in equal atoms, and, indeed, atom with atom, when there was only one compound of the two elements; if several, one atom of one substance combined with one, two, three, or more atoms of another. The first conception of these so-called multiple proportions originated properly with Higgins, who made it known as early as 1789, in a work on the subject. But the most important experiments, by which the theory of Dalton was proved, were instituted by Wollaston, who published in the year 1814 his ingenious scale of chemical equivalents.

When the numbers made use of by Dalton are compared with those which Berzelius deduced from his own accurate experiments, differences are found similar to those existing between these latter and those given by Richter. The number of analyses upon which Dalton had founded his arguments was too small, and moreover they had not been executed with very great accuracy.

In the selection of a substance to be taken as unity, so as to make the atomic weights found, comparable with each other, chemists have hesitated between hydrogen and oxygen. Dalton chose hydrogen, and took it as 1, since its atom is the lightest of all the elements. Many chemists followed his example on this account, especially after Prout subsequently had attempted to shew that the atomic weights of all simple bodies were multiples of that of hydrogen. Richter had long before entertained a similar view, inasmuch as he assumed that the equivalents of all bases form an arithmetical, those of acids a geometrical progression. Nevertheless, Berzelius and Wollaston took oxygen as unity, because it was the most widely distributed of all the elements, and

existed in most compound substances. By adopting oxygen as unity, all calculations were greatly simplified. Berzelius took it as 100, Wollaston as 10. Berzelius remained true to his opinion to the last, and always declared himself against that of Prout, even when, in 1840, it was again adopted by Dumas, who attempted to prove its truth for at least a few elements by actual experiment. It is true that the atomic weights of several of the non-metallic elements appear to be multiples of that of hydrogen, but it has not been possible to maintain Prout's views as regards others. So long as we are ignorant whether this correspondence is merely accidental, or actually a law of nature, we must suspend a decision.

In the determination of the number of atoms in compound bodies, Berzelius proceeded with great caution. Dalton and others, who had put forward the view that substances combine especially in such proportions that one atom of one element unites with one atom of another, assumed also that when, for example, several oxyds of an element existed, the oxygen atoms of the higher oxyds were multiples of oxygen in the lowest oxyd. But when only one oxyd was known, it was obviously very hazardous to assume that it consisted of equal atoms of both elements, without taking any notice of the other relations of this compound. Berzelius studied all the circumstances with the greatest attention, and the caution as well as penetrating tact with which he proceeded, are evident from the fact, that, when subsequently, Mitscherlich, by his important discovery of Isomorphism, furnished an admirable means of recognizing with certainty bodies having similar atomic composition, it was not necessary for Berzelius to make any alteration in his views.

Only upon one occasion did he feel himself compelled to modify his views regarding the arrangement of atoms in compound bodies. On the first establishment of his system, he was of opinion that in simple compounds, such as oxyds, there must be the most simple proportion, and the relation of two atoms of the radical to three of oxygen appeared to him to be too complex. Since in the oxyds of iron the oxygen was in proportion of two to three, he assumed that peroxyd of iron consisted of one atom of metal and three atoms of oxygen, the protoxyd and all those similar to it as consisting of one atom of metal and two atoms of oxygen. It was not until later in the year 1827, that Berzelius, particularly influenced by the proportions of the elements in the oxyds of manganese, chromium, and sulphur, decided upon assuming, that, in the strongly basic or so-called electro-positive oxyds, there was but one atom of metal and one atom of oxygen, and, consequently, that the atomic weights formerly adopted by him must be reduced to one-half. The higher oxyds, such as peroxyd of

iron, would then contain three atoms of oxygen to two atoms of metal.

At that time, Berzelius adopted the view, that when a simple body is converted into the gaseous state, one volume of the gas corresponds to an atom. For this reason, water was always regarded by him as composed of one atom of oxygen and two atoms of hydrogen. He held this opinion firmly, and disputed the hypotheses of Thomson, Dalton, and other chemists, who assumed that in two volumes of hydrogen there were as many atoms as in one volume of oxygen. Subsequently, when by the direct determination of the specific weights of sulphur, phosphorus, and mercury vapors, made by Dumas and Mitscherlich, this assumption of Berzelius was not generally confirmed, he limited its application to the permanent gases alone.

He was on this account compelled frequently to assume two atoms where other chemists assumed only one atom. He therefore introduced double atoms in those cases where they were the equivalent for one atom of another substance. Many chemists especially in Germany, have not followed this view; and Leop. Gmelin, in the last edition of his "*Handbuch*," as well as Liebig and his followers, have commenced to take the atomic weights of hydrogen, nitrogen, chlorine, bromine, iodine, fluorine, and phosphorus, as double those adopted by Berzelius; many French chemists also entertain this view. The assumption that the so-called equivalents are identical in meaning with the term atoms, has indeed so much probability, that the agreement of so many chemists in this respect cannot be remarkable.

Notwithstanding this, Berzelius continued to the last to adhere to his old atomic weights, and the reasons which, in the last edition of his *Lehrbuch*, he has assigned for doing this, are so strong, that they cannot well be set aside. These he derives especially from the isomorphism of perchlorates and permanganates as proved by Mitscherlich, and from which it follows that a double atom of chlorine can replace a double atom of manganese. Since, however, manganese is in its compounds isomorphous with iron and chromium, (for instance, in the alums,) and since chromium in chromates has the same form as sulphates, a simple atom of chlorine must be able to replace an atom of sulphur. But if perchloric acid consists of a double atom of chlorine, combined with seven atoms of oxygen, then the hypochlorous acid contains only one atom of oxygen, combined with the same quantity of chlorine as in the perchloric; and as hypochlorous acid consists of two volumes of chlorine and one volume of oxygen, the volumes of the two elements must correspond with the simple atoms. Moreover, since it appears to have been proved, by often-repeated experiments with organic bodies, that their hydrogen can be replaced by an equal volume of chlorine, a simple, and not a double, atom

of hydrogen must be able to replace one atom of oxygen or sulphur.

Even if it does sometimes happen that we do not find conclusions of this kind confirmed by experiment, if in the replacement of one body by another in compounds, an element, as for instance potassium, may be replaced by a compound radical such as ammonium, still it is not admissible to assume that such substitutions as may be theoretically inferred from the similarity in atomic weight, or atomic volume, really do take place, without the authority of repeated experiment. It is certainly convenient to regard equivalent and atom as synonymous terms, although not truly appropriate in a scientific view.

For the purpose of expressing the proportions in which bodies combine chemically, Berzelius, so early as the year 1815, employed certain signs as symbols for the different elements. Such signs were employed long before this in chemistry, or rather alchemy, although they were then of little value. These symbols undoubtedly owed their origin to the mysterious relation between the planets and metals, as assumed by the alchemists, and the pleasure which they took in expressing themselves in a manner unintelligible to the people. Berzelius would not adopt the old symbols, not only because they were, in fact, destitute of all significance, but likewise because it is certainly easier to write the abbreviation of a word than to draw a figure. The symbols of Berzelius, however, serve to express the chemical combining proportions, and the chemical formulæ furnish a means of representing the numerical results of an analysis with all the simplicity of an algebraical formula.

The system of symbols introduced by Berzelius has met with such universal recognition, on account of its extraordinary convenience, that there is probably no chemist who does not now employ it; and this renders it the more remarkable, that the opposition made to this innovation was at first so considerable. A French philosopher exchanged the symbols proposed by Berzelius, for the initial letters of the French names for the elements. But it was in England that the greatest opposition was made to the adoption of the chemical formulæ of Berzelius. Even so late as 1822, an English chemist, speaking of them, said, "they are calculated more to produce misunderstanding and mystification than clearness, since they are of a nature totally different from algebraical formulæ; it would be easier to express oneself in ordinary words than with these symbols, which only make a kind of mathematical parade." Berzelius replied to the partly rude and uncourteous objections with dispassionate clearness and composure. Who would now consider it possible to dispense with the use of these "abominable symbols" of Berzelius, as they were

termed by the editor of an English journal? The opposition to the introduction of these symbols was the more remarkable, since Dalton, in putting forward his atomic system in 1808, had felt the urgent necessity of representing the atoms of elements by means of symbols, which did not then meet with any opposition, although at the same time with no imitation in England. The symbols of Dalton are, however, far less appropriate than those of Berzelius; moreover, they sufficed only to express simple combinations, and not very complicated ones. The introduction of Berzelius's symbols first enabled the chemist to construct chemical formulæ.

When Berzelius began to prove the law of chemical proportions by experiment, he was so firmly convinced that in inorganic bodies only the most simple relations obtained, that he even doubted the accuracy of his own experiments, when their results gave complicated relations. It was long before he could allow himself to admit that simple substances could combine with three, five, and seven atoms of oxygen, because these numbers were not multiples of each other. He therefore assumed, that in phosphoric acid there were four atoms of oxygen, in the arsenious and arsenic acid four and six atoms, and in oxide of antimony and antimonic acid the same number; and long after he had convinced himself of the elementary nature of chlorine, he doubted the correct statement of Stadion, that hyperchloric acid contained seven atoms of oxygen.

The examination of the oyxds of nitrogen presented considerable difficulties to him. As ammonia was analogous to the fixed alkalies, and under the influence of galvanic electricity yielded an amalgam with mercury, there was a possibility of assuming that this was a process of reduction, and that ammonia consisted of a metal and oxygen. But when ammonia was decomposed, no oxygen was obtained, but only nitrogen and hydrogen: the oxygen must therefore, Berzelius inferred, be concealed in these gases and one or both must be oxyds of the same radical, and this radical the metal ammonium. But if nitrogen alone were the oxydized body, then the metal ammonium must consist of the radical of nitrogen and hydrogen. Then, again, at that time several chemists, especially Gay-Lussac and Thenard, assumed that potassium and sodium contained hydrogen; however, in the controversy which arose on this point between these chemists and Davy, who sought to disprove their view, Berzelius immediately decided in favor of the latter, and supported him with very strong arguments. He also assumed, on this account, the presence of oxygen in hydrogen, and this, as well as nitrogen, were, according to his view, oxyds of the metal ammonium. The different stages of oxydation were, according to him, the following: hydrogen, pro-

toxyd of ammonium (the present amidogen combined with potassium), ammonia, nitrogen, nitrous acid, nitric acid, and, finally, water, the highest oxyd of the radical, which, however, must, on this view, have contained 72 times as much oxygen as the lowest oxyd hydrogen.

Berzelius was led to adopt this extravagant but ingenious view by too great faith in the doctrine of proportions in the form in which he then conceived it. Somewhat later, he retracted the opinion that hydrogen was an oyxd, and demonstrated the elementary nature of this body by weighty arguments; but he still continued to regard nitrogen as containing oxygen, and endeavored afterwards to prove this by means of its oxyds. Even in 1818, in a paper upon the nature of nitrogen, hydrogen and ammonia, he said, "I venture to assert, that the compound nature of nitrogen must not be regarded as a mere hypothesis, but, if the doctrine of definite proportions is admitted, as a demonstrated truth." He assumed that an unknown radical—nitricum—existed, to which he assigned the symbol N, subsequently retained for nitrogen, which was then regarded as the suboxyd of this supposed radical, and the highest oxyd—nitric acid—as containing six atoms of oxygen.

It was, however, in truth, the circumstance that the proportion of the oxygen in nitrous acid to that in nitric acid was as 3 to 5, which alone misled him so obstinately to assert the existence of oxygen in nitrogen, in which case that proportion would have been as 4 to 6. When a short time afterwards he made his researches on the composition of phosphorus and phosphoric acids, in which he found, almost simultaneously with Dulong, that the quantities of oxygen were in the proportion of 3 to 5, and after having in vain attempted to detect oxygen in phosphorus, his views respecting the compound nature of nitrogen were shaken, and he finally relinquished them, after having convinced himself that a similar relation obtained between very many, we may perhaps now say most, of the different oxyds of simple bodies which form acids. Subsequently, he sometimes made the remark, without, however, assigning any particular importance to it, that from the production of nitrogenious compounds in the organisms of herbivorous animals, whose food frequently appears not to correspond in composition with them, the existence of oxygen in nitrogen might be inferred. However, in the last edition of his "Lehrbuch," even this remark does not occur.

This too great faith in the extreme simplicity of chemical combining proportions induced Berzelius, in some other instances, to assume the existence of oxyds which had no reality. In the investigation of the oxyds of tin, he assumed that the oxyd obtained from the Spiritus Libavii, which certainly differs greatly in its

characters from that obtained by means of nitric acid, was, in reference to the quantity of oxygen which it contained, intermediate between the protoxyd and peroxyd. Shortly afterwards Gay-Lussac shewed that it did not differ from the oxyd prepared with nitric acid in its quantity of oxygen. After Berzelius had convinced himself of the truth of this remark, he showed how much the two differed in their characters. This was the first example of Isomerism.

Berzelius connected the electro-chemical doctrine with that of simple definite proportions. It was very natural that he should apply the phenomena presented by the voltaic pile, and especially the facts which in his first paper he had so convincingly explained, to the ordinary chemical processes. He assumed, that in every chemical process there was a neutralization of the opposite electricities, in consequence of which heat and light were produced in the same way as in the discharge of a Leyden jar, the galvanic battery, or lightning, with the difference, that these phenomena were not always accompanied by chemical combination.

Even at the very first, Berzelius did not conceal from himself the difficulties which this theory involved. He assumed that the atoms possessed electrical polarity, upon which depended the electro-chemical phenomena attending their combination. Thus, the atoms of oxygen were regarded as having a preponderance of negative electricity; those of potassium a preponderance of positive. The unequal intensity of the electrical polarity in the atoms of different bodies, dependent partly upon their temperature, was regarded as the cause of the difference of force with which affinities are exercised. He altered his views of this subject at different times, and finally admitted that it was very possible that he was in error.

In classifying bodies as electro-positive and electro-negative, Berzelius regarded oxygen and the elements resembling it as electro-positive. Subsequently, however, he altered the nomenclature, and more correctly called them electro-negative. Oxygen alone he regarded as absolutely electro-negative, all other bodies being only relatively negative or positive, just as they would be related to each other when their compounds were exposed to the influence of the electric pile.

These views of Berzelius have been frequently disputed. And in truth, the phenomena attending the greater number of ordinary chemical processes, in which bodies act upon each other only when in immediate contact, are different from those which occur during the discharge of an electric pile where bodies act at a distance. It is only in some chemical processes, such as the arborescent deposition of metals, that there is a resemblance to the decompositions effected by the pile.

Much later, Berzelius assumed the existence of another force, although only as regarded some special chemical changes—the catalytic force. The evolution of light and heat, according to the electro-chemical theory, could only result from the combination of bodies opposite in their characters; but when they occur in the decomposition of bodies, or when compounds are decomposed and new ones formed, while at the same time the body whose presence causes this change takes no part in it, Berzelius ascribed this effect to the force of catalysis.

Much has been brought forward in opposition to the assumption of this new hypothetical force. But it is not justly censurable that, in an imperfect science like chemistry, all phenomena which stand isolated, for which no suitable analogues can be found, and which appear as it were wonderful, should provisionally be ascribed to a peculiar cause or force, so as openly to admit, that in the present state of the science it is more appropriate not to explain a chemical process at all, than to do so in a forced and fastidious manner. With the advance of the science, the number of phenomena belonging to such categories will always become smaller.

After Berzelius had labored uninterruptedly during a space of ten years in the investigation of the atomic weights, of the elements and their compounds, and had these so far established that all experiments corresponded to within small and unavoidable errors, he was in a position in 1818 to publish tables containing the atomic weights of about 2000 simple and compound bodies.

Thus had Berzelius completed, as it were, the scaffolding of his system, and he now commenced to supply the deficiences which he had previously been obliged to pass over, and thus to plan out the whole.

Sometime before, in 1814, he had also extended his investigations to organic substances, and published a very important paper on the definite proportion in which the elements are combined in organic nature. He there shewed at length, that however different organic bodies might at first sight appear to be from inorganic, in regard to their elementary composition, still the only certain clue by which we could hope to arrive at a correct conception of the nature of the composition of those bodies which are produced under the influence of vital processes, was what was already known of the composition of inorganic bodies. He had therefore the great merit of having extended the doctrine of the simple chemical proportions in which bodies combine to organic bodies.

The first accurate experiments on the elementary composition of organic bodies had been instituted a few years previous to the appearance of this paper, by Thenard and Gay-Lussac, in 1811. Nevertheless, they contented themselves with drawing no other inference from their results than that a vegetable substance is al-

ways acid when it contains oxygen in a proportion greater than is necessary to form water; that by an excess of hydrogen, resinous, oleaginous, or alcoholic substances were formed; and lastly, that when oxygen and hydrogen were present in the same proportions as in water, these substances were neither acid nor resinous, but analogous to sugar, gum, starch, milk sugar, or woody fibre. These conclusions were correct, only for the substances which they examined, and proved untenable when a greater number had been studied. From the results of their investigation of animal substances, they could not draw even similar inferences; they contented themselves with remarking, that they contained a greater quantity of hydrogen than was necessary to form water with the oxygen present, and that it was united with nitrogen in the form of ammonia.

Gay-Lussac and Thenard had burnt the organic substances by means of chlorate of potash, in a special form of apparatus; Berzelius borrowed from them the use of chlorate of potash, but his mode of combustion was incomparably more advantageous. He had already become convinced that it was necessary to estimate the carbonic acid obtained by its weight, and not by the volume. This was not always observed afterwards, on which account the analysis of organic bodies did not yield accurate results until a few years since, when Liebig introduced the extremely advantageous potash apparatus, which rendered it possible to weigh the carbonic acid with accuracy. Moreover, Berzelius estimated the hydrogen, not in the indirect way, like Gay-Lussac and Thenard, but he weighed it directly after it had been converted into water, which gave the results of his investigations a far greater accuracy in respect to this element.

The number of organic substances investigated by Berzelius was not very great, because the construction of apparatus, and the novelty of the subject presented many difficulties. But although afterwards the methods of analysis were greatly simplified and improved, still the analytical results obtained by him in his investigation of organic substances have proved to be remarkably accurate.

He shewed that, not only the organic acid, but also the indifferent substances, combined with inorganic oxyds in definite proportions, forming compounds resembling salts, by means of which their atomic weights could be determined, as in the case of inorganic bodies. This observation led to the view which regards organic bodies as oxyds, whose radicals, however, are compound, while in the inorganic bodies they are simple. This view at first attracted little notice among chemists, and was not till long afterwards recognized as correct by many, after the number of fantastic ideas of the composition of organic bodies had created an earnest desire for a rational and consistent theory.

It is a subject of regret, that it was not granted to Berzelius to live to see several of the radicals hypothetically assumed by him, actually obtained, as was done indeed but a very short time after his death.

Soon after the establishment of the electro-chemical system, Berzelius applied the theory of chemical proportions to minerals, and put forward a mineral system, based upon chemical principles. If the minerals occurring in nature are regarded as having compositions similar to the substances artificially prepared in the laboratory, such a mineral system is, indeed, very appropriate. Every man of science must, however, admit that in this case a different system of classification must come into use in Mineralogy from that adopted in Botany and Zoology. The inorganic substances with which that science has to do consist of a large number —more than 60—simple bodies: the organic substances, on the contrary, of very few—only three or four. Since, moreover, the intimate connection existing between the chemical composition and all the external characters of minerals cannot be detected, it is obvious that minerals might be more easily and certainly recognized, distinguished and classified, as soon as their chemical composition was studied; but not so plants and animals, in the case of which we do not yet know that there is such an intimate connection, and which, notwithstanding the greatest diversity in form, have almost all the same composition. Were it possible, likewise, to recognize their species by means of an easy chemical analysis, we should call every botanist and zoologist one-sided who neglected to avail himself of this means of recognition.

Before Berzelius's time, it had often been attempted to classify minerals according to their constituents, but before the doctrine of definite proportions, and the correct views of the composition of bodies were known, this could only be imperfectly effected. Such systems were those which Karsten had put forward in his mineralogical tables, and Hauy, in his mineralogy: but the achievements of Berzelius in this respect, caused the attempts of his predecessors to be entirely forgotten.

The mineral system put forward by Berzelius met with opposition, especially from those who followed the so-called natural systems.

In the natural systems of mineralogy, the minerals are all placed according to their similarity in external characters. But all these differed from each other, because they were constructed in accordance with subjective principles.

Werner had, in addition, based his natural system, to a certain extent, upon chemical principles, which were not carried out very consistently, as indeed was impossible, considering the state in which the science then was. But Mohs put forward the fundamental principle, that mineralogists should only pay attention to

the natural history characters of minerals, such as crystalline form, hardness, specific gravity, and not to such as cannot be observed without causing a sensible alteration in the substance. If it ever happens,—continues Mohs,—that a branch of natural history as mineralogy, employs such characters in its method as these last mentioned, it then exceeds its legitimate bounds, becomes entangled with other sciences, and hampered with all those difficulties of which mineralogy has long been a warning example.

Berzelius criticised this argument with justice. He declared that it seemed to him the same as if a man who is stumbling in the dark, should hesitate to make use of a light, because he would then see more than he required, and because he hoped to find his way without it.

In order to appreciate fully the great merit of Berzelius, in putting forward his mineral system, it is only necessary to call to mind how great was the chaos in mineralogy before his time, and especially with regard to the classification of the numerous compounds of silica. Although both Döbereiner and Smithson commenced to regard silica as an acid, at about the same time as Berzelius, still it was he who first made an extended application of this view, in the new mineral system which he proposed, by means of which siliceous minerals were included under the head of saline compounds, and the correct conception of their composition first rendered possible.

The greater number of natural compounds of silica are double salts; and observing the great diversity among them, Berzelius raised the question, as to whether it was probable that the individual members of such double salts were different stages of saturation. As he had previously assumed only the most simple relations in chemical compounds, he was at first led to infer upon theoretical grounds, that the existence of dissimilar stages of saturation in the double salts of silica, was less probable, especially as he had never met with any similar phenomena in his investigations of the double salts of other acids. Nevertheless, he subsequently altered this view, after he had himself first prepared the remarkable double salt of neutral carbonate of magnesia, and bicarbonate of potash.

The salts of silicic acid, and indeed all true compounds occurring in natural as well as artificially prepared salts, received formulæ which expressed their composition. But as Berzelius was long doubtful how many atoms of oxygen he should assume in silica, and even when he afterwards decided for three atoms, did not regard this assumption as perfectly certain, he introduced more simple formulæ for siliceous compounds, which he termed mineralogical, and distinguished from the chemical formulæ by the printers' type employed.

The establishment of correct formulæ, especially for siliceous compounds, involved great difficulties, since the composition of very few minerals was known with any degree of certainty. The first quantitative analyses of minerals were made by Torbern Bergman, but according to such imperfect methods, that they scarcely indicated anything more than the qualitative composition. After these came the analyses of Klaproth, which compared with those of Bergman were a considerable and encouraging advance, for he had not only employed better methods of investigation, but also worked with much greater accuracy. But even the analyses of Klaproth as well as those of Vauquelin and others, who worked simultaneously with him, when put to the test of definite chemical proportions, were not found to be unquestionable. It is true, that at first Berzelius could very often only propose a conjectural formula for the composition of many minerals, and generally only after making slight alterations in the results of the then known analyses, in doing which, however, he always proceeded with great caution. Afterwards these incorrect analyses were replaced by correct ones, and especially by Berzelius himself and his pupils, who employed in their analyses the most accurate methods proposed by him.

Berzelius first arranged minerals according to their electro-positive constituents. But after Mitscherlich's discovery of isomorphism, which has exerted so important an influence upon the arrangement of the system, he considered it more advantageous to classify minerals according to their electro-negative constituents, because the substitution of isomophous substances is far more frequent among the bases than among the acids; and therefore the classification according to the electro-negative constituents corresponded more with the requirements of mineralogists. Both methods have their advantages: they are equally philosophical, and may be employed with equal justice; it was therefore with great injustice that Berzelius was charged with inconsistency in making this alteration.

The mineral system of Berzelius is not even yet completed. He was far from wishing to affirm that it was incapable of improvement; on the other hand, during his whole after-life he continually improved it, and from time to time published it in a more perfect form. The last edition was superintended by Rammelsberg, in 1847, at the request of Berzelius.

The most important modifications still to be made on this system, are perhaps those which would result from a simple application of the doctrine of isomorphism. It is certainly difficult to harmonize the opinions as to the best method of doing this.

Berzelius was not quite right in affirming that the constituents of a substance alone must determine its place in a system. Even in the last "*Jahresberichte*" published by him, he

declares that, in a mineral system, the sole question for consideration is the elements and their inorganic combinations, and that it is these which must be systematically arranged. But he himself directs attention to the difficulties which this view necessarily involves. Is it, he asks, admissible to make one species of diamond and graphite, or of rutile, brookite, and anatase, or of calcareous spar and arragonite? It is scarcely to be expected that mineralogists will give their consent to such a course.

However, Berzelius decides in the affirmative. Still I am of opinion that there are even many chemists who will not unconditionally agree with him in this. For it is not alone from the constituents that all the characteristic properties of the compound result, but also from the mode and action of their combination, which is frequently indicated by the form. Taking all this into consideration, it appears probable that dolomite is more closely related to calcareous spar than arragonite, and even that tinstone is nearer to rutile than anatase and Brookite.

Since the external characters of minerals are determined, as well by their constituents as by the mode in which these are combined with each other, it follows that that chemical system of mineralogy which approaches most closely to the natural systems, or which even corresponds with them, must be the most perfect.

(*To be continued.*)

Art. XX.—*Artificial Formation of Minerals;* by N. S. Manross.

[This memoir—an inaugural dissertation by Mr. Manross on his promotion to the rank of Doctor of Philosophy at the Georgia-Augusta University (32 pp., 8vo, Göttingen, 1852)—contains an account of the artificial formation of several minerals. The experiments were made in the Laboratory of Prof. Wöhler. We cite briefly the processes followed by Dr. Manross and his results.]

Heavy Spar ($\dot{B}a\bar{S}$) was obtained by fusing together twelve grammes of neutral sulphate of potash and 52 grammes of anhydrous chlorid of barium in a thin porcelain crucible, this being enclosed in a Hessian crucible which was well luted. After an hour, on treating the cooled mass with water, an abundance of minute crystals were left behind which had the form of heavy spar, giving $M : M = 101° 43'$. Some of them were two millimetres long and one thick. Analysis afforded $\bar{S}$ 34·32, $\dot{B}a$ 65·57, =99·89.

Celestine ($\dot{S}r\bar{S}$) was formed by fusing together sulphate of potash with an excess of chlorid of strontium. On breaking open the cooled mass many transparent crystals were seen. They were separated as before by dissolving the excess of chlorid in

water. The largest were two to three mm. long, but these were uneven. The smaller were brilliant and perfect. The crystals were usually elongated in the direction of the shorter diagonal, M : M = 104° 11′. There were many compound crystals crossing at angles nearly of 41°, and also six-rayed stars. There were also cruciform crystals, in which each bar was itself a compound crystal, with reëntering angles at the end, and a hopper-shaped cavity at the center of the cross. Analysis afforded the usual constitution.

Anhydrite ($\dot{C}a\,\ddot{S}$).—Fifteen or twenty grammes of neutral sulphate of potash were fused with four or five times as much chlorid of calcium. The surface of the cake obtained, appeared after cooling, covered with a film of crystalline plates, and on breaking it, there were cavities occupied by groups of rectangular crystals, several millimeters long and two broad, but scarcely thicker than letter paper. Analysis afforded $\dot{C}a$ 41·44, $\ddot{S}$ 58·50 = 99·94.

Apatite.—Daubrée obtained apatite in microscopic crystals by passing chlorid of phosphorus over caustic lime at a red heat (Comptes Rendus, xxxii, 615). Dr. Manross fused phosphate of soda (first rendered anhydrous) with an excess of a mixture of chlorid of calcium and finely powdered fluor spar. The resulting mass was full of slender transparent hexagonal prisms, sometimes a millimeter long, many of which ended in a pyramid formed on the angles; angle over the summit 68° 15′—which is the angle of one of the pyramids that occurs in apatite. No analysis could be made on account of the difficulty of separating the crystals from the fluor spar.

In another trial, phosphate of soda was fused with fluor spar and slender six-sided needles were obtained.

In a third, 10 grammes of phosphate of soda were fused with 50 of chlorid of calcium. The crystals thus obtained were hexagonal, usually terminated by pyramids, a face of which made with a prismatic plane the angle 129° 7′, which differs more than a degree from the angle of apatite. G. = 3·054. Analysis afforded Cl 13·02, Ca 7·36, $\dot{C}a^3\ddot{P}$ 79·10 = 99·48, which requires the formula $3\dot{C}a^3\ddot{P} + 2Ca\,Cl$.

Pyromorphite ($3\dot{P}b^3\ddot{P} + Pb\,Cl$).—Ten grammes of tribasic phosphate of soda were fused with 70 grammes of chlorid of lead. While the temperature was still above the fusing point of chlorid of lead the fluid contents were poured out, and the interior was found to be lined with light yellow transparent and brilliant hexagonal prisms, three to five mm. long, terminating in pyramids; angle between the pyramidal planes and the prismatic 130° 23′, which is within 1′ of the angle given for pyromorphite. G. = 7·008. Analysis confirmed the result.

Wolfram ($(\dot{F}e, \dot{M}n)\ddot{W}$).—Finely powdered native wolfram may be recrystallized by fusing with a considerable quantity of chlorid of sodium. The heat applied was such as to evaporate

most of the chlorid. The mineral formed a dark stratum in the bottom of the crucible, and the crystals were in brilliant grains and beaded crystals, not admitting of measurement.

Tungsten ($\dot{C}a\,\dot{W}$).—Neutral tungstate of soda was fused with an excess of pure chlorid of calcium in a Hessian crucible. After a strong heat for half an hour, it was allowed to cool gradually. White glittering grains were obtained which were unmodified square octahedrons; angle over a basal edge 130° 20′. G.= 6·0759. In one case when the heat applied was rather low and the cooling somewhat rapid, the tungsten was in the form of needles, each needle being made up of a series of octahedrons, 44 of which were counted in one needle. Analyses gave $\dot{W}$ 80·42, $\dot{C}a$ 19·58.

Scheelelite ($\dot{P}b\,\dot{W}$).—Ten grammes of tungstate of soda were fused with 47 of chlorid of lead. In the dark green mass there were cavities lined with brilliant crystals which were square octahedrons; angle over a terminal edge, 99° 46′. There were planes of another octahedron at the summits. G.=8·232 and 8·238. Composition $\dot{P}b$ 46·65, $\dot{W}$ 53·35.

Wulfenite ($\dot{P}b\,\ddot{M}o$).—Hausmann has described this mineral as occurring in the walls of a furnace at Bleiberg in Carinthia. (Ann. Ch. u. Pharm., lxxxi, 224). Four grammes of neutral molybdate of soda were fused with 24 of chlorid of lead. The crystals obtained appeared like hexagonal plates with unequal angles. They were pale yellow, and some of them more than two millimeters across. On dissolving the excess of chlorid of lead, square octahedrons were found, many of which were tabular by the enlargement of two opposite faces. Angle over a terminal edge 99° 43′. G.=6·811. Analysis gave 60·59 p. c. of lead.

Crocoisite ($\dot{P}b\,\dot{C}r$).—In the first trials the heat was too high and the chromic acid was mostly reduced to oxyd. In another trial transparent crystals were formed, having the color of the native chromate. G.=6·118. Streak orange-yellow. Analysis $\dot{C}r$ 32·763 $\dot{P}b$ 67·239=100·002.

Anglesite ($\dot{P}b\,\ddot{S}$).—By fusing together neutral sulphate of potash and an excess of chlorid of lead, crystals were obtained which had the tabular form and many of the modifications of sulphate of lead. As the result was not quite satisfactory, a more successful trial was made in the wet way.

A solution of sulphate of potash was prepared, forming a stratum an inch deep in a tall beaker glass. Several inches of pure water were carefully filtered upon this stratum so as to leave it undisturbed. A few grammes of chlorid of lead were fused to a cake and suspended by a platinum wire, just within the surface of the fluid. It was then set aside for some weeks. At first a white cloud was formed when the stream of dissolved chlorid reached the solution of sulphate below. But as the latter became diffused through the fluid, the cake of chlorid, and even

the platinum wire, became covered with a growth of tabular crystals. Some of them attained a length of from one to two millimeters in the course of three weeks. The sides of the glass were also covered with brilliant crystals, but only above the zone first occupied by the solution of sulphate. A considerable portion of the chlorid remained undissolved even after several weeks time had elapsed. It would undoubtedly be practicable to obtain crystals of any desirable size by this process.

The form of the crystals was that of an elongated table terminated by faces of the primary octahedron. The angle 0P : P was 115° 32′, agreeing with that of the natural mineral.

Before the blowpipe, the crystals decrepitated strongly and gave with soda the reaction of sulphuric acid, and a globule of lead. No further examination was made of them.

ART. XXI.—*On the Probable number of the Native Indian Population of British America;** by Capt. J. H. LEFROY, R. A.

THERE are probably few persons who, in the course of their reading in history, have not dwelt with peculiar interest upon the glimpses we catch through the mists of the past, of whole races of men that have vanished from the face of the earth, leaving no heirs or representatives to inherit the richer blessings of our age: of nations whose part in the great drama of human life we can never ascertain, whose sages are forgotten, whose warriors lie with "the mighty that were before Agamemnon" in the obscurity of oblivion. Then we may remember "how small a part of time we share" whose interests are so momentous for eternity; and may recognize, in the force of our sympathy, in the eagerness with which we interrogate the monuments that have descended to us; in the curiosity which all their reserve cannot baffle; a testimony to the truth of the declaration of the sacred historian, that the Creator "hath made of one blood all the nations upon earth;" as well as the tie of relationship which unites all the descendants of our common parents, whatever their place in the stream, or their fortunes on the stage of life.

Naturalists have been able to number some half-dozen birds or animals that have become totally extinct within the period of authentic history. We have lately seen what general rejoicing the discovery of a living specimen of one previously ranked in that number (the *Apteryx*) has created among them. The skull, the foot, and a few rude pictures of the Dodo, have furnished ample material for a quarto volume. How many might be written on

* From the Proceedings of the Canadian Institute.

the varieties of the human race that have ceased to exist within the same period! The Dodo was very common at the Isles de Bourbon two centuries ago; it was neglected, hunted down, and finally exterminated: and the Dutch seamen who made an easy prey of whole flocks, twenty or thirty at a time, in 1602, (the Dodo, page 15,) no more suspected that we should now be ransacking all the museums of Europe for scraps to elucidate its affinities, than the first settlers of Newfoundland did that we should also be seeking in vain for one relic of its aborigines. When happy and hospitable crowds welcomed the Spaniards to the shores of Hispaniola, those cavaliers little dreamt that in three centuries or less the numerous and warlike Caribs of that Island, like the Gauchos of the Canaries, would be extinct, as completely so as the Architects of the Cyclopian remains of Italy, or the race that preceded Saxon, and Dane, and Celt, in the occupation of the British Isles. In half a century there will be no trace of a native race in some of the British colonies in the east. The natives of Van Diemens Land, for example, who numbered 210 in 1835, were reduced to 38 in 1848.* It even appears doubtful whether that most interesting of all savage races, the Maoris of New Zealand, with its wonderful force of character, and faculty for civilization, will not die out faster than it can conform to its altered condition. Like those silent yet ceaseless operations of nature, which are wearing down, while we speak, the solid matter of every mountain chain, and substituting the luxuriant vegetation of the tropical coral reef for the barren waste of the sea; so, slowly and imperceptibly, are the great changes effected, by which one race supersedes another in the occupation of portion after portion of the globe, bringing higher qualities, a different moral and physical organization, to work out higher destinies, and fulfill higher ends of the same controlling Providence.

These reflections have been suggested by the subject of the paper which I now propose to lay before this Society, containing the result of some enquiries I have made with a view to forming something like an authentic estimate of the number of the Indian race inhabiting the British possessions in America:—a portion only, it is true, of the whole race, yet one which by reason of the great extent of those possessions, is commonly regarded as a very important one. If, as I think it can be shown, that number is vastly smaller than most persons would suppose, and very rapidly diminishing, under circumstances which are nevertheless by no means unfavorable to its preservation; then it must be admitted that the prospects for the race at large are anything but encouraging; that the time may not be far remote when posterity may be counting its last remnants, and wishing that we in our day had been more alive to the facts, and more industrious in setting up

* Our Antipodes, by Colonel G. Mundy, 1852, vol. ii.

marks by which they might measure the ebbing tide, and comprehend the destiny about to be consummated.

What constitutes density of population, is a question not easy to answer, when it relates to civilized communities, so wonderfully has Providence ordained that with fresh demands, and the heavier pressure of necessity, fresh resources should be found in nature for human sustenance; but in reference to uncivilized man, linked to nature by stronger ties, and having his existence bound up, as it were, with those of her provisions which do not greatly vary from age to age, and are not so beyond our means of estimation, it does not seem impossible to assign limits beyond which his numbers can never far extend, and within which there is no reason that they should much vary, unless by the operation of external causes. However, I have no intention of attempting such an estimate here. We have evidence in the great earthworks of Ohio, requiring an immense number of hands for their construction, that at some period a considerable population occupied the fertile valleys of that region. We know that agricultural pursuits prevailed among many tribes, which have since almost completely abandoned them; but with all this, it is difficult to avoid the conclusion, based on the desolating habits of Indian warfare, on the severity of the climate, and on the degraded position of the female sex, that upon the whole, the population of the middle and northern portion of the continent must, at all times, have been small in proportion to its area, and never on a par with the simplest of all natural resources, the animal life of the region.

The materials for a specific estimate of their numbers at any one early period, are exceedingly scanty. The early travellers dealt in round numbers to an alarming extent. "*Qui dit un Canton d'Iroquois*" says de la Hontan, "*dit un douzaine milliers d'ames. It s'en est trouve jusqu'a quatorze mille et l'on calculait ce nombre par deux mille Vieillards, quatre mille Femmes, deux mille Filles, et quatre mille Enfans.*" And as there were then five such cantons, or Nations, this people, if the Baron or his authorities can be trusted, counted, considerably less than two centuries ago, from sixty to seventy thousand souls. Yet he gives as informants persons who had lived twenty years among them. Little reliance can be placed on the estimate: the ancient *Coureurs des Bois* were addicted to romancing; and the habit of perverting facts in reference to the more remote tribes they visited, by way of discouraging rivalry in their lucrative trade, must have clung to them when discussing those nearer home. Equally apochryphal, I cannot but suspect, must be the 20,000 warriors, whom King Oppecancanough somewhat earlier, is related to have led against the settlers in Virginia. Yet these, and other similar statements, which it would be easy to multiply, if they fail to furnish a numerical basis for comparison, convey a general idea of populousness, which, as compared with what is known of our

times, would justify anything that can be said as to the decline of the race. "There are abundant proofs," says Catlin, "in the history of the country, to which I need not at this time more particularly refer, to show that the very numerous and respectable part of the human family, which occupied the different parts of North America, at the time of its first settlement by Anglo-Americans, contained more than *fourteen millions*, who have been reduced since that time, and undoubtedly in consequence of that settlement, to *something less than two millions*." (Catlin, ii, p. 238.) In the elaborate alphabetical enumeration of Indian tribes and nations, upwards of 400 in number, prefixed to Drake's well-known Book of the Indians: 10th Edit., 1848—we find the estimated numbers of a large proportion of them stated, but being of a great variety of dates, and the data probably of very variable authority, no general estimate can be based on it, without an analysis much more laborious than the result is likely to be accurate.

In the course of a couple of summers spent a few years ago in the Hudson's Bay territory, I took pains to arrive at an estimate of the actual numbers of Indians inhabiting that country, by enquiries among the resident traders, and by procuring, whenever possible, a specific statement of the number of hunters frequenting each Post, the number of young unmarried men, and an estimate of their families. The first two were, no doubt, ascertained very correctly, as far as the enquiry went; the last does not admit of much doubt. With respect to the districts which I visited, but from which I did not procure these data, it is not difficult to base a tolerable approximation on the information derived from observation and inquiry; and in respect to those which I did not visit, which, however, form but a small part of the territory, I am guided in the estimate by the facts that where there are no trading posts, there are no Indians, and that where there are trading posts, all the Indians of the district frequent them, habit having rendered the articles of European trade essential to their existence; consequently we may infer the number frequenting any given post pretty nearly when the scale of the establishment is known. There are, perhaps, a few exceptions to this remark in the district of Mackenzie's River, where our intercourse with many tribes is of recent origin; but it is true almost everywhere else. Whenever a conjectural addition was made, by well informed persons on the spot to the more precise numbers, it has been included in the following enumeration.

The British territory, in relation to its native population, may be divided into four regions. *First.*—The region west of the Rocky Mountains, and north of the parallel of 49°. *Second.*—The region east of the Rocky Mountains, but north of the parallel of 55°; the whole of which is inhabited by tribes of a common origin, and grouped by Ethnologists under the generic designation of "Tinnè." *Third.*—The region from the parallel

of 55° to 49°, occupied partly by tribes of what is called the Eythinyuwuk or Algonquin stock, and partly by tribes of an intrusive race, kindred to the Iroquois or Five Nations. Lastly,—the British Colonies.

Beginning with the *Second* of these subdivisions, we have—North of Latitude 55° :

	Men.	Estim'd Total.	
(1.) Esquimaux—*Inu-it* not included	Unk'n		
(2.) Loucheux—*Kutchin*			
On the Youcon and tributaries,—			
" Richardson, Artez-Kutchi	100		
" p. 234. Tchue	100		
" On the Tathzey	230		
" authority of Kutchcha	90		
" Mr. Murray Zi-Unka	20		
" Tanna	100		
" 1850. Teytsè	100		
" Vanta	80		
" Neyetsè	40		
	860		
On Peel's River, 1844	413	5000	
Fort Good Hope Mountain Indians	75	375	
Loucheux	15	75	
Francis Lake, 1847–8	45	210	
Pelly Banks "	73	368	
		6028	
(3.) Dogribs, Hares, Chipewyans, &c. *Tinnè*			
Fort Good Hope, Lowland Indians	28	150	
" Rapid Indians	11	55	
Fort Norman Da-ha-Dinne, Dog-rib, Hare	140	600	
Fort Simpson—Hares	107		
" Do. Irregular	320		
" Dog-rib	10		
" Do. Irregular	50		
" Nahanies	2		
" Do. Irregular	4	2400	
Fort Liard*—Hay River Indians, (Hares,)	20		
" Beaver or Chipewyan	30		
" Slaves or Hares	10		
" Thecanies	30		
" Nahanies	14	600	
Fort Resolution—Chipewyans	80	420	
" Yellow Knife	51	260	
Big Island or Great Slave Lake Hares	20	100	
Fort Chipewyan, Chipewyans	140	730	
Vermillion Beaver Indians	62	250	
Dunvegan Beaver Indians	87		
" Seccanies	4		
Chipewyans	12	350	
Unenumerated Chipewyan Stations			
Churchill	100	400	
Isle a la Crosse†	110	660	
Dog-rib and Martin's Lake Indians, said by Mr. Isbester not to be decreasing in numbers	150	600	7575

* Franklin gave, in 1820, 685 hunters.

† Franklin rated them at 200 men and boys.

The foregoing enumeration, although it embraces a large extent of country, does not bring us into contact with the more numerous tribes, which are to be found only on the plains, where countless herds of Buffalo furnish ample means of subsistence. Without going into any nicety of classification, founded upon affinities of race, upon which subject Dr. Latham and Sir John Richardson (Arctic Expedition) have given much information, the tribes are referred to here by the designations they commonly bear among the traders. Mr. Harriet, then, a gentleman who had passed his life among them, estimated the six or seven tribes going by the general name of Blackfeet, as mustering 1,600 to 1,700 tents, at 8 per tent, 13,200.

Mr. Rowland, one of the oldest resident traders, gives them thus:—Sir John Franklin's estimate in 1820, is added—

		Franklin, 1820.
Blackfeet, proper, - - -	300	350
Pe-a-gans, - - - -	400	400
Blood Indians, - - -	250	300
Gros Ventres, or Fall Indians, -	400	500
Circees, - - - -	45	150
Cotones, } Mountain Tribes, }	100	
Small Robes, }	150	
	1645 at 8 p. t.	13,160
Mr. Shaw allowed to the Blackfeet, only - -		12,000

Considering that these are perfectly independent estimates, they agree remarkably, and we may take by their mean—

The Blackfeet tribes, - - - - 12,900

We have next the Assiniboines, a tribe of the Sioux, and said to be of the Iroquois stock: they are distinguished into those frequenting the woods, and those frequenting the plains, or Strongwood and Plain Assiniboines:

Mr. Harriet, in 1842, gave Strongwood -	80 tents.	
Mr. Rowland gave Plain Assiniboines, -	300	3,200
Mr. Shaw gave, both together - -		4,000
Giving for Assiniboines - - -		3,600

	Tents.	
For the Strongwood Crees about Edmonton, Mr. Rowland gave, - - -	100	4,000
Other Crees of the plains, - - - -	200	2,000
Mr. Shaw gave, - - - - - - -		4,000
(3.) Crees, - - - - - - - -		3,500
(4.) Ojibwas, or Chippewas of the Saskatchawan—Mr. Rowland, - - -	20 -	200

I. The aggregate, then, of the tribes inhabiting the Plains, in the British Territory, by competent authorities was, in 1843, not

more than 23,400. Catlin's estimate for the same tribes, is 35,000; but I found that all his numbers were regarded by better authorities (for Mr. Catlin did not visit the region here in question,) as too high.

II. We have next the various divisions of that widely diffused race, the *Eythinyuwuk* or Crees, which form the population of the wooded country east of the Great Plains, and south of the Churchill River, extending however in some instances *on* to the one, and *north* of the other. The Crees of the Plains we have already counted. There are a few Crees trading at Fort Chipewyan, at Isle a la Crosse, and at Lesser Slave Lake.

	Families.	Souls.
At Fort Chipewyan, - -	26	140
" Lesser Slave Lake, - -	83	341*
" Isle a la Crosse, and Green Lake,	100	600
" Cumberland House, - -		300†
" The Pas, or Basquan, - -		150†
" Norway House, - - -		300†
" Oxford House, - - -		100†
" York Factory, - - -		200†
" Beren's River, - - -		100†
" Red River dependencies, -		2000†
" Albany River, Martin's Falls,		500†
" Moose Factory and outposts,		500†
" Lake Tamiscaming, - -		200†
		5431

To this division belong the Chippewas or Ojibwas, Saulteurs, and Tetes de Boule of Lake Superior, Lake Huron, and their tributary waters. It was ascertained by the Honorable W. B. Robinson, Indian Commissioner in 1851, that the Indians on the north side of Lake Superior, from the Sault St. Mary to Pigeon River, and inland as far as the possessions of the Hudson's Bay Company, forming six bands, or subdivisions, were in all 1102 souls; and that the Indians on the north side of Lake Huron, from the Sault to French River, forming 17 bands, amounted to 1,422 souls, giving a total of 2,521. The bands were found to vary much in number, some comprising no more than 15, some as many as 241 souls. We have then—

	Souls.
Brought forward, - - - -	5,431
At Fort Alexander—Lake Winnepeg, -	200†
" Rat Portage—Lake of the Woods, -	120†
" Fort Francis—Rainy Lake, - -	400†
" Lake Superior, as above, - - -	1,102
" Lake Huron, as above, - - -	1,422
	8,675

* About one-third half-breeds. † Estimates only.

With respect to the Indians in Canada proper, it is stated in a very interesting report concerning them, (Journals of House of Assembly, 1844–5, Appendix 2,) that the earliest document received by the Government, which contains any detailed statement relative to the tribes, is one prepared by Major-General Darling, Military Secretary to Lord Dalhousie, in 1828. The total number of Indians who then came under the observation, and within the influence of the Government, in both Provinces, did not exceed 18,000. I am indebted to Col S. P. Jarvis, late Indian Superintendent, for the following authentic returns of their more recent numbers. In 1835, the number of resident Indians receiving presents, as they are improperly called, being rather annuities or rent charges upon the soil of Upper Canada, was stated as follows:

TABLE I.

	Men.	Women.	Boys und'r 15.	Girls und'r 15.	Total
Iroquois, or Six Nation Indians, including the Mohawks on the Bay of Quinté	598	727	543	545	2413
Hurons, or Wyandots	25	25	10	18	78
Chippewas	414	438	313	276	1441
Chippewas, called Mississaugus	208	246	157	125	736
Munsees, Delaware, or Lenne-le-nape	44	51	36	26	158
Moravian Indians	78	79	55	44	256
	1397	1566	1114	1035	5082

The following table contains a statement in detail of the Indians in Upper Canada in 1838, compiled from a return made in answer to enquiries of the Secretary of State for the Colonies, (Lord Glenelg.) The corresponding numbers in 1844 and 1846, where they are given under the same denomination, are added from the returns of the Indian Department.

TABLE II.

Indians of Upper Canada. The details are from the very complete returns of 1838, unless otherwise stated; and where corresponding totals are not given for the years 1844 and 1846, it arises from a more general form having been adopted in those years.

	DENOMINATION.	1838.					1844.	1846.
		Men.	Women.	Under 15. Boys.	Under 15. Girls.	Total	Total.	Total.
	CHIPPEWAS.							
1	St. Clair Rapids	113	124	84	85	396	197	
2	Walpole Island or Chenail Ecarté	47	60	28	39	176	307	1129*
3	R. au Sables Lake Huron	11	6	4	10	27	117	
4	Up. St. Clair from Saginong	80	92	68	52	312	"	
	The same in 1844	218	234	159	130	"	741	684

* Pottawatomies and Ottawas are here included.

TABLE II.—(*Continued.*)

	DENOMINATION.	1838.					1844.	1846.
		Men.	Women.	Under 15. Boys.	Girls.	Total	Total	Total.
5	Amherstburg	28	32	25	15	100	258	494*
6	Delaware, River Thames	121	120	79	57	377	378	438
7	Manitoulin Island, L. Huron	64	61	25	38	188	"	"
	The same in 1846	284	330	229	255	"	"	1098*
8	LaCloche and Mississaugeen	69	77	59	20	225	"	"
9	St. Joseph's Island, Lake Huron	23	26	17	24	90	"	"
10	Sault Ste. Marie	24	36	19	20	99	"	"
11	East Shore of Lake Huron	68	59	49	26	202	"	"
12	Owen's Sound, in 1846	42	54	20	20	"	"	139
13	Saugeen, Lake Huron	55	57	55	51	218	"	209
14	Yellowhead's Tribe, Rama	83	103	35	21	242	267	327
15	John Aisence's Tribe, do.	54	74	36	20	184	211	213
16	Lake Nipissing	18	16	10	15	59	"	"
	MISSISSAUGAS.							
17	River Credit, L. Ontario	68	77	52	43	240	254	245
18	Rice Lake	35	47	28	25	135	145	151
19	Mud Lake; Balsam Lake	45	52	35	27	159	175	194
20	Alnwick; on Rice Lake, from Grape Isl'd	63	71	45	35	214	233	218
21	Bedford, near Kingston, 1846	26	24	10	19	"	"	79
	IROQUOIS, OR SIX NATIONS, *on the Grand River.*							
22	Mohawks, Upper	81	105	87	90	363	374	406
23	" Lower	67	72	60	61	260	310	336
24	" from the Bay of Quinté	19	24	23	25	91	94	88
25	" on the Bay of Quinté	87	74	77	99	337	354	415
26	Oneidas, Joseph's	16	19	5	17	57	42	42
27	Onondagas, Clear Sky	51	68	36	25	178	219	225
28	" Bear or Barefoot	17	28	11	12	68	64	56
29	Senecas, Nekarontasas	8	13	11	10	42	55	70
30	" Kaghneghtasas	13	18	13	10	54	52	43
31	Cayugas, Upper	45	31	23	25	124	114	117
32	" Lower	105	97	48	69	319	287	311
33	Tuscaroras	38	55	30	39	162	192	202
34	Aughquagas, Joseph's	13	22	18	17	70	82	67
35	" Peter Green	23	22	20	22	87	75	68
36	Tutulies or Tutiloes	15	17	6	9	47	40	32
37	Minor denominations	12	28	22	25	87	96	102
	OTHER TRIBES.							
38	Ottawas, Manitoulin Island	26	22	14	18	80	"	"
39	Hurons, or Wyandots	34	21	13	17	85	88	"
40	Munsees, or Delawares	2	2	1	1	6	22	"
41	" on River Thames	64	74	55	49	242	242	157
42	" on Grand River	42	54	18	26	140	127	122
43	Potawatomies, at Saugeen	55	57	55	51	218	"	"
44	" St. Clair Rapids, 1844	141	170	101	94	"	507	"
45	" Upper St. Clair, 1846	27	33	21	14	"	"	95
46	Shawanoes, at Amherstburg	2	4	"	"	6	"	"
47	Moravian Indians, River Thames	41	42	29	31	143	143	187

The total numbers, as they appear at the foot of the above returns, exclusive of what are termed visiting Indians, most, or all of whom, come from regions beyond Lake Superior, and, if British Indians, are included elsewhere—are as follows:

* Pottawatomies and Ottawas are here included.

TABLE.

	1838	1844	1846	1847
Deserving Chiefs	52	31	29	
Warriors	38	38	51	
Women	62	41	41	
Ordinary Chiefs	134	162	178	
Warriors	1712	1274	2207	
Women	2091	2131	2599	
Boys, 10 to 15 years	422	492	573	
" 5 to 9 "	430	475	595	
" 1 to 4 "	553	433	690	
Girls, 10 to 14 "	310	421	455	
" 5 to 9 "	442	444	567	
" 1 to 4 "	497	481	773	
Totals	6643	6874	8756	8862

The Chiefs and Warriors in the first class, are those who served in the last war. The numbers in 1847 are taken from the Quebec *Gazette*. The apparent increase in 1846 is due to the permanent settlement of many Indians within the Province, previously residing beyond its limits, and was occasioned, as is well known, by the objection made on the part of the United States to our continuing to supply arms and ammunition to friendly natives belonging to their territory; the details of the table, however, when they are comparable, give satisfactory grounds for supposing that as regards the small portion of the Indian race inhabiting Canada, the worst is over. They appear to be slightly on the increase, and are at the same time acquiring to some extent the habits of civilized life.*

The following table of the number of Indians in Lower Canada, is taken from the Report presented to the Legislative Assembly, 1845, (Journal 1844–5, App. 2,) to which reference has been made before:

DENOMINATION.	Men.	Women.	Boys. 15 to 10.	Boys. 9 to 5.	Boys. under 5.	Girls. 15 to 10.	Girls. 9 to 5.	Girls. under 5.	Total
Iroquois, Caughnawaga	266	306	61	67	72	53	66	64	955
" St. Regis, L. St. Francis	118	127	33	35	33	17	33	54	450
" Lake of Two Mountains	87	103	17	19	24	22	21	23	316
Algonquins, Lake of Two Mountains	95	116	23	20	19	29	26	5	332
" near Three Rivers	25	34	5	9	10	3	3	9	92
Nipissings, Lake of Two Mountains	75	85	23	15	12	17	29	7	263
Abenequais, St. Francis	100	111	14	27	32	14	26	26	353
" Becancœur	24	33	7	5	3	2	7	2	84
Hurons or Wyandots, la Jeune Lorette	64	55	8	6	11	16	13	16	189
Tetes de Boule, St. Maurice	31	22	1	10	8	6	6	3	86
Micmacs, Abenequois, and Amaleites, of uncertain residence	63	66	11	7			3	28	180
Totals	950	1058	203	220	224	179	233	234	2401

* The fact that the Mohawk Chief, John Brant, was once elected member of the House of Assembly, although he lost his seat for want of sufficient freehold property, deserves to be remembered.

It is to be regretted that the Lower Canadian returns do not distinguish the Iroquois according to the distinct nations of that once powerful confederacy. It will be observed, however, that the above numbers, combined with those of the Upper Canada return for 1846, make the number of chiefs and warriors still to amount to 1,220, and the total number to 4,301*. That their ancient loyalty to the British Crown is unabated, was shown by many incidents of the Canada rebellion, and by the language of their chiefs on the very interesting occasion of the meeting to restore General Brock's Monument in 1841. There is no native race entitled to claim, on so many grounds, the interest and respect of British inhabitants of Canada.

The following numbers of Indians in the several Counties, taken from the Census Returns of 1852, are added, to bring down the information on that subject to the latest date. It is evident, however, that the enumerators in Upper Canada did not always distinguish them from the rest of the population. There are, for example, none returned for the counties of Lambton and Essex, on the St. Clair,—thus the total is far below the truth,—but the list appears to be complete for lower Canada.

UPPER CANADA.—1852.		LOWER CANADA.—1852.	
Brant	1758	Beauharnois	754
Carleton	20	Bonaventure	451
Dundas	54	Champlain	31
Grey	374	Drummond	27
Grenville	48	Huntingdon	1259
Haldimand	310	Kamouraska	55
Kent	259	L'Islet	21
Northumberland	222	Megantic	14
Peel	12	Montmorency	26
Perth	8	Ottawa	5
	3065	Portneuf	12
		Quebec	218
		Rimouski	103
		Saguenay	663
		Terrebonne	11
		Two Mountains	408
			4058

The number of Indians on the lower St. Lawrence, frequenting the King's posts of the Hudson's Bay Company, is not known, but must be insignificant. I believe this to be also the case of the Indians in Nova Scotia and New Brunswick, but have no access, at present, to authentic returns.

We have still to consider the population west of the Rocky Mountains, in New Caledonia.

* The Mohawks of the Bay of Quintè are included, but the Delaware of the Thames are excluded, as never belonging to the Six Nations, although at present associated with them in all the returns of the Indian Department.

In 1820, Harmon, who had lived long among them, stated that the number, of all ages, did not exceed 5,000; they have diminished since with fearful rapidity, probably faster in that quarter than in any other. Mr. McGillivray, in Ross Cox's Travels, of somewhat earlier date, makes the tribes inhabiting the country about Frazer's River, the most populous part of the country, to number no more than 1,012 souls, including the Chilcotins, Naskotins, Tolkotins, and Atnahs—four tribes. Captain Wilkes, in 1840, upon a very careful survey, and doubtless upon much more complete and authentic data, than either of the others, makes the total population of Oregon and New Caledonia together, amount to 19,354 souls, about two-thirds of whom M. Duflot de Mofras estimates for Oregon alone. So that on the whole, I consider that 2,000 for the interior of New Caledonia, (Oregon no longer being British territory,) is an ample allowance.

We have also to include the large Islands of Quadra or Vancouver's, and Queen Charlotte, together with the seaboard of that region. The population of the former has been estimated at from 10,000 to 20,000, and that of the latter at from 7,000 to 10,000.

By the kindness of Mr. Kane, whose labors as an artist in the least known parts of this continent, have yet to be fully appreciated, I am enabled to present an abstract of a very full census of Indian tribes inhabiting the northwest coast, which he procured in 1847. If it can claim anything like the general accuracy and fidelity of his pictures of Indian life, we need not hesitate to adopt it.

TABLE III.

COMMON DESIGNATION AMONG THE TRADERS.	Tribes.	ADULTS.		CHILDREN.		Slaves.	Houses
		Men.	Wom.	Boys.	Girls.		
Nass Indians*	4	543	438	314	308	12	32
Chimseyans	10	737	778	465	466	68	257
Skeena Indians	2	131	72	64	59		30
Sabassas	5	474	407	243	194	111	
Milbank Sound Indians†	9	1007	961	394	462	47	122
Chilcat, &c‡	7	1249	961	469	418	479	
Stekene Indians§	8	562	410	240	190	144	59
Port Stuart‖	3	180	185	141	157	15	37
Kygarney¶	6	431	454	414	436		111
Queen Charlotte Sound**	6	1029	1035	962	1003		257
About Queen Charlotte Sound††	25	7370	8890	9949	11491	1472	735
Cape Scot and vicinity	4	730	875	1290	1290	210	74
Total		14443	15466	14972	16474	2558	1724

* Trade at Fort Simpson, Vancouver's Island, and generally reside in its vicinity.
† Trade at Fort McLaughlin.
‡ Trade at Sitka, Sitkene and Tacca.
§ Trade generally at Stikene, but frequently visit Fort Simpson.
‖ Trade generally at Fort Simpson.
¶ Frequent Ft. Simpson Stikene, Zacca and Sitka.
** Frequent Fort Simpson. †† Frequent Fort McLaughlin.

We may now proceed to reckon up the result, not forgetting that the region under discussion is equal in extent to one-twentieth part of the habitable surface of the globe, and has been generally looked upon as the asylum and stronghold of the race of North American Indians. Excluding the Esquimaux, whose numbers, notwithstanding the great extent of sea-line they occupy, cannot be large—probably not more that two or three thousand—we have the following enumeration:

Chipewyan tribes, namely, Chipewyans proper, Dog-ribs, Hare or Slave Indians, Yellow Knives, Beaver Indians, Da-ha-dinnies, and Carriers, - - - -	7,575
Northern Indians of the *Kutchin* stock, - - -	6,028
Ethiny-u-wuk Indians of the Plains, - - - -	23,400
Chipeways and Crees, exclusive of the above, - -	8,675
Indians of the Seaboard and Islands of the Pacific, -	63,840
Indians of New Caledonia—interior, - - - -	2,000
Indians of Canada, - - - - - - - -	13,000
Grand Total, - - - - - - -	124,518

Or to drop the appearance of precision conveyed by the broken numbers, 125,000, being barely double the number at which De la Hontan estimated the Six Nations of the Iroquois alone, in 1690.

I am conscious that this number, for the gross population of so large a portion of the whole Continent, may appear almost incredibly small. In going over carefully and reconsidering the details, I do not believe them to be, upon the whole, under estimated. No important region of the British territory appears to be omitted. It is presented, therefore, as an approximation, which may at least serve to direct further attention to the subject. It is, of course, to be taken as representing only a portion of the race. I have no means of estimating the native population of Russian America, and we have not considered the native population of the United States, Texas, Mexico, and Oregon. The first of these was estimated in 1835 at 330,000, which, however, I take to be too high. Mr. Cuthbertson, a naturalist, travelling for the Smithsonian Institution at Washington, gives the following for the probable number of Indians on the Upper Missouri and its tributaries, in 1850. (Fifth Annual Report of Board of Regents, 1851.)

Sioux, - - - - - - -	30,000
Cheyene, - - - - - - -	3,000
Ariccaree, - - - - - -	15,000
Mandan, - - - - - - -	150
Gros Ventres, - - - - -	700
Assiniboine, - - - - -	4,800
Crow, - - - - - - -	4,800
Blackfoot, - - - - -	9,800
Total, - - - - -	54,550

Among whom appear to be included some of those frequenting the British trading posts, and previously reckoned. It is scarcely possible that the Indians of the Lower Missouri, Texas, and Mexico, can make up even an approximation to the 330,000 of the Baptist Committee. (Religion in America, p. 56.) Putting the whole together, it would scarcely seem that the present aggregate can be placed so high as 250,000, instead of the two millions of Catlin.

To this remnant, then, has been reduced a race supposed to have numbered from ten to twenty millions, not more than three centuries ago. "War, death, or sickness hath laid seige to it," and is still laying seige at a rate in no degree less rapid than at any former period. Not to mention the cruel destruction effected by the American fur traders and trappers in the South; by utter lawlessness and wanton disregard of humanity; by Florida wars and wholesale deportations; we find that even in regions where the more obviously depopulating agencies have been held in great restraint, the process goes on. The Indians themselves are fully aware of it, and fully conscious also that the whites cannot always be directly charged with it. Sir John Richardson has given us a curious mythological tradition which serves to account for it to the Kutchin, (p. 239.) A friend of mine, who conferred on the subject with a sage old native of New Caledonia, found that his only theory was that the white men's tobacco poisoned them. The white's fire water in this case, and throughout the Hudson's Bay territory, is happily guiltless, for none enters the country.* If we charge it, in the case of the Carrier, to the unbounded licentiousness which prevails among them, we have to account for the same causes not having had the same effect at earlier periods; for, with the sole exception of the Indians of Virginia, boundless licentiousness appears to have been the rule among the natives on our first acquaintance with them. The travels of Lewis and Clark beyond the Mississippi, only half a century ago, fully corroborate the accounts of all travellers of the seventeenth century in Canada and the more Eastern regions, in respect to this characteristic.

Doubtless, some causes can be assigned, which tend to reduce the physical stamina of the race—such as the substitution of inferior European clothing for their native robes of fur; the use of stimulants, tobacco almost universally, alcohol partially; the gradual loss of native arts and appliances, without the acquirement of anything better; the introduction of new forms of disease; a marked deterioration in their dwellings, from the skins of

* I cannot avoid referring Temperance advocates to the amusing Essay, "Sur l'Yvrognerie des Sauvages," in the Histoire de l'eau-de-vie en Canada, 1705; reprinted by the Literary and Historical Society of Quebec. It is well to know that, *il n'y a qu'une mesure d'yvresse qu'ils appellent* Ganontiouaratonseri, c'est a dire, *Yvrognerie pleine!*

which they were formerly made acquiring a market value, but being exchanged for nothing so essential to their health. There are also moral causes tending to depress the race—such as the consciousness of decline; the pressure of new necessities; the hopeless sense of inferiority to the whites in many respects, which, with all their reputed pride, is a general feeling among the Indians. Lastly, we must add the influence of practices which have a frightful prevalence in certain districts. I mean the administration of potions destined sometimes to produce abortion, sometimes to cause absolute sterility, in females. Dr. Hodder, in an Essay on the Poisonous Plants of Canada, read since the date of this paper, has alluded to the former as one of the secrets of the Indians in Canada, which he has not succeeded in discovering, but to which he attributes, in a very great degree, their decrease in number. Many instances of the latter were related to me in the interior—the Crees, more particularly, have a bad eminence as medicine men, which shews a general disposition among them to the unnatural arts. In fact, they are stated to be among the commonest resources of jealousy and revenge. However, some of these causes have not been found to check the reproductiveness of other races; and it may be doubted whether any or all of them are adequate to explain the broad fact, the final solution of which can probably be found only in the supposition of a design of Providence to make way for one race by removing the other.

ART. XXII.—*On the Constitution and Equivalent Volume of some Mineral species;* by T. S. HUNT, of the Geological Commission of Canada.

IN a recent paper, we have endeavored to lay down some principles as the basis of a sound theory of chemistry.* Having explained the nature of chemical changes, and the laws of combination, we showed that the volumes of the uniting species are always merged in that of the new one, so that the atomic theory, as applied by Dalton, which makes combination consist in juxta-

* This Journal for March, 1853, p. 226, and London Phil. Mag. for June, Supplement, p. 526. The readers of that article in this Journal will please make the following corrections: p. 226, 10th line from the bottom, for *the capacity of such changes*, read *the capacity of such complete change*, etc.; and in the last line of the next page, for *it transcends the limits of human knowledge*, read *it transcends all sensible knowledge*.

The term *metagenesis*, found on page 227, has been used by Owen to designate that multiform or serial generation observed in many of the lower orders of life; this, however, is not strictly a metagenesis, and the term if not rightly understood may lead to grave errors. As applied to chemical transformations, it appears, however, to be unobjectionable.

position, is untenable. It was further asserted, that the simple relations of volumes which Gay Lussac pointed out in the chemical changes of gases, apply to all liquid and solid species, thus leading the way to a correct understanding of the equivalent volumes of the latter. While chemists have not hesitated to assign high equivalents to bodies of the carbon series, they have been inclined to make the equivalent weights of denser mineral species correspond to formulas representing the simplest possible ratios. We have endeavored from a consideration of the theory of equivalent volumes, to point out the errors to which this method has led, and to show that we must assign to most mineral species much higher equivalent weights than have hitherto been admitted.

It was further asserted, that a relation similar to that observed in the formulas of allied hydro-carbonaceous bodies, and designated as chemical homology, exists in the formulas of mineral species. We have said that these formulas, deduced from the results of analysis, are not to be looked upon as expressing any pre-existing relations in the constitution of the species, which is not to be regarded as a compound, but as an individual, in which the so-called chemical elements have no actual existence. The arrangements of these in our formulas, only serve to make apparent the numerical relations which have been found to govern the transformations of the higher species.

The formulas of homologous bodies may be represented as series in arithmetical progression. The first term may be the same as the common difference, and the series is then

$$b,\ 2b,\ 3b \ldots nb,$$

as in the hydrocarbons C_2H_2, C_4H_4, C_6H_6, etc. If the first term is unlike the common difference, the series is

$$a,\ a+b,\ a+2b, \ldots a+nb,$$

of which the ammonias, NH_3, $NH_3+C_2H_2$, $NH_3+2C_2H_2$, etc., are examples. Both of these cases are illustrated in the chemical history of mineral species.

In the paper already referred to, it has been shown, from the relations of carbon, sulphur and oxygen on the one hand, and of hydrogen with the metals on the other, that M_2S_2, M_2O_2, and H_2O_2 (M representing any metal), may be compared with H_2C_2. This view will be applied in extending the application of the principle of homology. The sesqui-oxyds like ferric oxyd, chromic oxyd, and alumina, will be regarded as oxyds of *ferricum*, *chromicum*, and *aluminicum*, having two-thirds the equivalents ordinarily assigned to these metals, and represented by fe, cr and al, so that Fe_2O_3, becomes 3feO, capable of replacing 3MgO, or 3FeO. In the same way arsenic and antimony in one-third their usual equivalents may be represented by as, sb, and AsO_3 becomes

3asO. Silica, SiO_3 may also be written as 3siO, for the multiple equivalent weight assigned to it, is deduced from certain silicious species whose formulas are as simply written with the lesser equivalent; by this means all these oxyds may be reduced to the type M_2O_2.

We have further asserted, that for species crystallizing in the same form, the density varies directly as the equivalent weight, so that the quantities obtained in dividing the one by the other, and known as the atomic or equivalent volume, will be equal. Such a relation is already recognized between species of the same genus, and we now propose, having fixed an equivalent weight for one species, to calculate from their densities, those of the species isomorphous with it, and to show from the formulas corresponding to these equivalent weights, that the different genera thus related are homologous, or exhibit other intimate relations.

In this investigation of mineral species, several circumstances combine to render the attainment of accurate results exceedingly difficult. Native crystals are often neither compact nor homogeneous, and the presence of fissures filled with air, or other foreign species, makes the determination of density uncertain. Impurities also render the results of analysis doubtful, and if we employ the formulas generally assigned, it will be found that an attempt to deduce the most simple relations from the results of analysis, or to make these conform to some arbitrary assumption, has led chemists to adopt numbers which are often considerably at variance with experiment, and to disregard one or two hundredths of some element, which is perhaps essential to the constitution of the species. This is probably in an especial manner true of the small portions of water and fluorine in certain silicates, which are determined together as the loss by ignition, and disregarded in the construction of the formulas. The uncertainty with regard to the equivalent weight of silica is also a source of embarrassment in the examination and comparison of formulas. According to Pelouze, SiO_3 is 45·34 (O=8) while the corrected determinations of Berzelius make it 46·22. The latter number, adopted by Rose in the tables accompanying the last edition of his Analytical Chemistry, will be employed for the calculation of equivalent weights in the present paper.

In many artificial crystals those difficulties are less felt, and the equivalent volumes are closely accordant. We cite for illustration the following results from an elaborate memoir on atomic volumes, by Playfair and Joule. (Qu. Jour. Chem. Soc., p. 121.) These phosphates and arseniates crystallize in the monoclinic system; the densities here given are the means of several determinations.

Species.	Formula.	Equiv. wt.	Density.	Volume.
Phosphate soda,	$PO_5Na_2H, 24HO$	359·1	1·525	235·5
Sub-phos. soda,	$PO_5Na_3, 24HO$	381·6	1·622	235·2
Arseniate soda,	$AsO_5Na_2H, 24HO$	402·9	1·736	233·0
Sub-arsen. soda,	$AsO_5Na_3, 24HO$	425·2	1·804	235·6

The four species of alum examined by these experimenters exhibit a similar relation. They are monometric in crystallization, and, like the last, are represented with 24HO, common alum being $S_4al_2KO_{16}, 24HO$; the al may be replaced by fe or cr, and the K by NH_4, as in the following species. The equivalents given by Playfair and Joule have been corrected from later determinations of chromium and aluminum.

Formula.	Equiv. wt.	Density.	Volume.
$S_4al_2KO_{16}, 24HO$	474·6	1·731	274·1
$S_4al_2(NH_4)O_{16}, 24HO$	453·4	1·625	279·0
$S_4cr_2KO_{16}, 24HO$	500·6	1·843	271·6
$S_4fe_2(NH_4)O_{16}, 24HO$	482·0	1·715	280·5

The densities here adopted are the means of those of several experimenters. Playfair and Joule, from different specimens of the same species, obtained results, some of which we cite to show the amount of variation in crystals of a pure salt. Thus, for potash alum the numbers 1·726 and 1·751 were obtained, giving respectively 275 and 271 for the volume; and for chrome alum, the densities 1·826 and 1·856, corresponding to 274·15 and 268·6. For reasons already given, the presumption in these salts is in favor of the greater density, adopting which, we have for the mean of the four species 274·6, and for the first three, 272·8, as the equivalent volume.

The monometric species leucite is represented by the formula $\dot{K}_2\ddot{S}i_2 + 3\ddot{A}l\ddot{S}i_2$, which expanded becomes $Si_8O_{24}, (al_2K_2)O_{12}$ with an equivalent of 665·22 and a density of 2·49, giving 267 for the volume. The triclinic species andesine, belonging to the same type, has an equivalent of 622·2 and a density of 2·7, giving 230·4 for its volume. This difference of volume in these and other dimorphous species has already been pointed out by Dana.

If we turn from the alums and leucite, to the chlorids of potassium and sodium, which likewise crystallize in the regular system, we find at first sight no apparent relation with the former, or between each other. The one NaCl, with an equivalent weight of 59·4, has a density of 2·257, which gives 26·3 for its volume, while the chlorid of potassium KCl, with an equivalent of 74·5, has a density of only 1·978, (P. and Joule,) giving a volume of 37·67. If we suppose crystallized sea salt to be 10NaCl, we shall have 263· for its volume, and the potassium salt may be 7KCl, with a volume of 265·7. We are thus led to the conclusion arrived at by Favre and Silbermann, from their experiments

upon the heat evolved in fusion and solution, that the equivalent weights of crystallized salts are multiples of those deduced from the analysis of these same salts in solution.

In order to establish a starting point, it will be necessary to determine the volumes of some species, whose combining proportions are known to be very high in proportion to their densities. Ferrocyanid of potassium, $C_{12}N_6Fe_2K_4$, 6HO, has an equivalent weight of 422·8 and a density of 1·832, giving 230 for its volume; milk-sugar, $C_{24}H_{24}O_{24}$, has an equivalent of 360, with a density of 1·534, and a volume of 234; and cane-sugar, $C_{24}H_{22}O_{22}$ gives 342, with a density of 1·593, and a volume of 215. These species approach to andesine in equivalent volume. The formula of the combining proportion of piperine, deduced from its platinic chlorid, is established by the researches of Wertheim, as corrected by Gerhardt, to be $C_{70}H_{36}N_2O_{10}$, to which in the monoclinic crystallized alkaloid, H_2O_2 is to be added, giving an equivalent weight of 582. I obtained for its density in three experiments with a carefully purified specimen, 1·238, 1·244 and 1·250, giving a mean of 1·244, which corresponds to an equivalent volume of 467·8, or double that calculated for andesine, the soda salts, and other prismatic species above. We may therefore double the equivalents of these species, as well as those of leucite and the alums. Their formulas and equivalent volumes will then be as follows:

Alum,	$S_8O_{24}(al_6K_2H_{48})O_{56}$	548·0
Sea-salt,	$Na_{20}Cl_{20}$	526·0
Chlorid of potassium,	$K_{14}Cl_{14}$	531·4
Leucite,	$Si_{16}O_{48}(al_{18}K_6)O_{24}$	534·0
Andesine,	$Si_{16}O_{48}(al_{18}Na_3Ca_2K)O_{24}$	460·8
Piperine,	$C_{72}H_{36}N_2O_{10}, H_2O_2$	467·8

The relation which we have seen between the alkaline chlorids is one of homology, similar to that between the hydrocarbons $n(C_2H_2)$, and an examination of some oxyds crystallizing in the regular system, will furnish further examples of the same relation. Magnetite $FeO, Fe_2O_3 = (Fe\,fe_2)O_4$, with a density of 5·094, gives a volume of 22·7; if we multiply its equivalent by twenty-four, it becomes $(Fe_{24}fe_{72})O_{96}$ with a volume of 544·8; several other species as franklinite, chromoferrite, martite, have a similar volume; but red copper ore CuO, with an equivalent weight of 71·4, and a density of 6, gives a volume of 11·9, so that its formula will be $Cu_{46}O_{46}$, with a volume of 547·4, while melaconite CuO, with an equivalent weight of 39·7, and a mean density 5·25, has a volume of 7·54, which gives for $Cu_{72}O_{72}$, a volume of 543·0. Arsenious acid AsO_3 with an equivalent weight of 99· and a density of 3·7, has a volume of 27·, giving for $As_{20}O_{60} = as_{60}O_{60}$, a volume of 540.

From these examples it appears that identity of volume in allied and isomorphous species, requires higher equivalents and more complex formulas than are generally assigned, and that these new formulas are homologous. We deduce the equivalent weight of a monometric species like that of a gaseous hydrocarbon from its density.

The rhombohedral species of the calcite group are commonly cited as example of identity in equivalent volume, but even this group presents exceptions such as we have seen in the monometric oxyds and chlorids. Calcite is remarkable for the variations in the density of different specimens. According to Beudant* the purest varieties give from 2·5239 to 2·7234. With the formula $C\,Ca\,O_3 = 50$ and a density of 2·72, the volume is 18·4, and with 2·52 it equals 19·84. The magnesite from Arendal which contains only ·73 p. c. of oxyd of iron, gave to Scheerer a density of 3·068; if we take 3 for the pure carbonate, the equivalent volume will be 14, and calamine with a density of 4·45, gives the same number. Dolomite of density 2·9 gives a volume of 15·9, and diallogite with a density of 3·592, equals 15·6, while spathic iron with a specific gravity of 3·8 has a volume of 15·2. We give here the volume and the angles of the rhombohedron for these species.

Species.	Volume.	Angle R : R.
Calamine,	14·0	107° 40′
Magnesite,	14·0	107° 22′
Spathic iron,	15·2	107°–107° 5′
Diallogite,	15·6	106° 51′. 107° 20′, Lévy and Breithaupt.
Dolomite,	15·9	106° 10′–106° 20′
Calcite,	18·4–19·8	105° 5′–105° 25′

Kopp has endeavored to connect these variations in volume with the different dimensions of the rhombohedron in the several species, but it seems probable on comparing the corrected numbers, that this apparent relation is accidental. Besides the variations in density presented by calcite, it will be seen that the difference between the angles of calamine and magnesite, whose volumes are identical, is the same as that between the latter and spathic iron; the angle assigned by Levy and Breithaupt to diallogite, differs only 2′ from that of magnesite, while the volume of the species is near that of dolomite. The importance to be attached to the small variations in angular measurement, is lessened by the differences in the angles of the same species, amounting to from 5′ to 20′, and by the variations observed by Nicklès in many artificial crystals, often amounting to 1° and 1° 30′, and seemingly dependent upon portions of foreign matters, sometimes too small to be detected by chemical analysis.†

*Annales des Mines, (2,) v. p. 275, cited in Dana's Mineralogy, 3d Ed. p. 206.

† Comptes Rend. des Trav., 1850, p. 193.

To the above series of isomorphous species, Rose has added soda-nitre, which has R : R 106° 33′, light red silver ore, proustite, having R : R 107° 36′, and dark red silver ore, pyrargyrite R : R 108° 18′. Soda-nitre $N\,Na\,O_6$ with a density of 2·26 (P. and Joule) gives 37·6 for its equivalent volume; proustite $(Ag\,S)_3 + As\,S_3$, with a density of 5·5, gives 91, while pyrargyrite, in which antimony replaces the arsenic of the last formula, has a density of 5·8 and a volume of 94.

This series then presents wide variations in volume, and it is only by adopting more elevated equivalent weights, that a simple relation becomes apparent. We shall endeavor to fix these equivalents as before from the densities of the species. The formulas of the silver ores are to be multiplied by six, for a reason which will be assigned farther on, and we have then for the formula of proustite, $Ag_{12}As_6S_{36}$ with a volume of 546, while the antimonial species, and soda-nitre $N_{15}Na_{15}O_{90}$ have each a volume of 564. Calamine then becomes $C_{10}Zn_{10}O_{120}$, with a volume of 560, magnesite being the same. Dolomite $C_{36}(Ca_{12}Mg_{12})O_{108}$ gives a volume of 554, and spathic iron $C_{36}Fe_{36}O_{108}=547$, while the diallogite of Kapnik is represented by $C_{36}(Mn_{32}Ca_{2\cdot5}Mg_{1\cdot5})O_{108}$, and with a density of 3·592, has a volume of 563. Calcite of the density 2·72, and the formula $C_{30}Ca_{30}O_{90}$, gives 555·5 for its volume, while that with a density of 2·52, may be represented by $C_{28}Ca_{28}O_{84}$, with a volume of 552. With these formulas it is apparent that there may be a great number of intermediate species from partial substitutions.

According to the above formulas, we have in the rhombohedral carbonates, several genera belonging to a homologous series of the first kind. These genera have the same volume, and are represented by the general formula $n\,C_2M_2O_6$; that of the nitrates is $N\,M\,O_6$, and light red silver ore $As\,Ag_3S_6 = as_2Ag_3S_6$, so that the general formulas of these three groups offer a very interesting resemblance, which was first pointed out by Gerhardt;* they are

$$n\,N\,M\,O_6$$
$$n\,C_2M_2O_6$$
$$n\,as_2M_3S_6$$

The arragonite group is not less worthy of notice, and Rose has shown that potash-nitre and bournonite are isomorphous with these prismatic carbonates. The density of this series is greater than that of the last; Rammelsberg's formula for Bournonite is $(3CuS, SbS_3)+2(3PbS, SbS_3)$ which equals $(Cu_3Pb_6)Sb_2S_{12}$; this with a density of 5·85, according to recent determinations by the same chemist, gives a volume of 254, which we double to compare with the volume of piperine, and with that adopted for leucite and the alums. Bournonite has the same chemical

* Comptes Rend. des Trav. de Chimie, 1849, p. 322.

type as the red silver ores, and it is to compare them with it, that we have multiplied the received formulas of these species by six.

Taking then 508 for the volume of bournonite, the formula of arragonite may be written $C_{30}Ca_{30}O_{90}$ with a volume of 510·; witherite is $C_{22}Ba_{22}O_{66}=503·8$, while strontianite is $C_{25}Sr_{25}O_{75}=505$, and cerusite has the same type and volume. Bromlite is represented by $C_{25}(Ca_{12·5}Ba_{12·5})O_{75}$ with a volume of 500, and barytocalcite, the monoclinic form of the species, gives for the same formula 507·5. Nitrate of potash with the formula $N_{10·5}K_{10·5}O_{63}$ has a volume of 506.

From the fact that it is here found necessary to assign a fractional value to n in the formulas of the nitrates and carbonates, we are led to infer that the equivalent weights here assumed, are as yet too low, and must at least be doubled. We however retain for the present, the fractional equivalents, and subjoin the formulas and calculated volumes of the two series.

Rhombohedral Species.

		Density.	Volume.
Proustite,	$As_6Ag_{18}S_{36}$	5·50	546
Pyrargyrite,	$Sb_6Ag_{18}S_{36}$	5·80	564
Soda-nitre,	$N_{15}Na_{15}O_{90}$	2·26	564
Calamine,	$C_{40}Zn_{40}O_{120}$	4·15	560
Magnesite,	$C_{40}Mg_{40}O_{120}$	3·00	560
Dolomite,	$C_{36}(Mg_{18}Ca_{18})O_{108}$	2·90	554
Spathic iron,	$C_{36}Fe_{36}O_{108}$	3·80	547
Diallogite,	$C_{36}(Mn_{32}Ca_{2·5}Mg_{1·5})O_{108}$	3·59	563
Calcite,	$C_{30}Ca_{30}O_{90}$	2·72	555·5
Do.,	$C_{28}Ca_{28}O_{84}$	2·52	552

Trimetric Species.

		Density.	Volume.
Bournonite,	$Sb_6(Cu_6Pb_{12})S_{36}$	5·85	508
Potash-nitre,	$N_{10·5}K_{10·5}O_{63}$	2·10	506
Arragonite,	$C_{30}Ca_{30}O_{90}$	2·93	510
Strontianite,	$C_{25}Sr_{25}O_{75}$	3·65	505
Cerusite,	$C_{25}Pb_{25}O_{75}$	6·60	505
Bromlite,	$C_{25}(Ba_{12·5}Ca_{12·5})O_{75}$	3·71	500
Witherite,	$C_{22}Ba_{22}O_{66}$	4·30	504

An interesting example of homology is afforded in the tourmalines whose composition has been well shown in the late admirable series of analyses by Rammelsberg. The ordinary rhombohedron of this species gives R : R 133° 26′ (132°—134°, Breithaupt,) but the rhombohedron 2R has the angle 103° 21′, or nearly that of calcite. Rammelsberg has analyzed thirty varieties of this species, all of which yield boracic acid in quantities varying from six to nine per cent., and from 1·3 to 2·7 per

cent. of fluorine. This last is given off by ignition as fluorid of silicon or boron, and the mineral then becomes soluble in hydrochloric acid. Rammelsberg admits that silicic and boracic acids replace each other, and finds that the ratios between the protoxyds, sesquioxyds, and the two acids, vary exceedingly in the different varieties. Without regarding the fluorine, he divides the species into the five following groups.*

1st. *Magnesia tourmalines.* $\dot{R}_3\ddot{S}i_2+3\dot{R}\ddot{S}i$; the mean equivalent weight deduced from six varieties is according to Rammelsberg 441·15 (O=8), and the mean density 3·05, giving an equivalent volume of 144·6.

2nd. *Magnesia-iron tourmalines.* $\dot{R}_3\ddot{S}i_2+4\dot{R}\ddot{S}i$, with a mean equivalent weight deduced from eight varieties of 518·81, and a mean density of 3·10, giving 167·3 for the equivalent volume.

3rd. *Iron tourmalines.* $\dot{R}_3\ddot{S}i_2+6\dot{R}\ddot{S}i$; the mean equivalent of six varieties is 777·20, and the mean density 3·2, giving 241 for the equivalent volume.

4th. *Iron-manganese tourmalines.* $\dot{R}\ddot{S}i+3\dot{R}\ddot{S}i$; the mean equivalent weight of six varieties was 360·36, and the mean density 3·08, giving a volume of 117·0.

5th. *Manganese tourmalines.* $\dot{R}\ddot{S}i+4\dot{R}\ddot{S}i$; the mean equivalent weight of four varieties was 449·3 and the mean density 3·04, giving 148 for the equivalent volume.

A red tourmaline from Rozena of density 2·998, yields according to Rammelsberg the formula $\dot{R}\ddot{S}i_2+5\dot{R}\ddot{S}i$.

If we represent R_2O_3 by 3rO, the formulas of these five groups become as follows:

1st. $Si_5O_{15}(R_3r_9)O_{12}$.
2nd. $Si_6O_{12}(R_3r_{12})O_{15}$.
3rd. $Si_8O_{24}(R_3r_{18})O_{45}$.
4th. $Si_4O_{12}(R\,r_9)O_{22}$.
5th. $Si_5O_{15}(R\,r_{12})O_{13}$.

Multiplying by four the formulas and equivalents of the 1st and 5th, so as to make Si_{20}, and then by a simple proportion raising the others to the same scale, we obtain the following formulas and equivalents.

		Mean equiv.	Mean D.	Eq. vol.
1st.	$Si_{20}O_{60}(R_{12}r_{36})O_{48}$	1764·6	3·05	578
2nd.	$Si_{20}O_{60}(R_{10}r_{40})O_{50}$	1729·2	3·10	558
3rd.	$Si_{20}O_{60}(R_7\frac{1}{2}r_{45})O_{52}\frac{1}{2}$	1928·0	3·20	602
4th.	$Si_{20}O_{60}(R_5r_{45})O_{50}$	1800·0	3·08	584
5th.	$Si_{20}O_{60}(R_4r_{48})O_{52}$	1799·6	3·04	592

It will be seen that the 2nd and 4th have similar formulas, and differ by R_2O_2 from the first, while the 3rd, rejecting as insig-

* Pogg. Annal., 1850, Nos. 8 and 9, and this Journal, vol. xi, p. 257.

nificant the fraction, is like the 5th, and differs from the 1st by R_4O_4. The tourmaline of Rozena is $Si_7O_{21}(R\ r_{15})O_{16}=Si_{28}O_{86}(R_3r_{43})O_{46}$, so that we have the four following homologous genera, the last two having each two species.

$Si_{28}O_{66}$, $M_{46}O_{46}=(si_{66}, r_{13}, R_3)O_{106}$.

$Si_{28}O_{66}$, $M_{48}O_{48}=(si_{66}, r_{36}, R_{12})O_{108}$.

$Si_{28}O_{66}$, $M_{50}O_{50}=(si_{66}, r_{40}, R_{10})O_{110}$, and $(si_{66}, r_{45}R_5)O_{110}$.

$Si_{28}O_{66}$, $M_{52}O_{52}=(si_{66}, r_{45}, R_7)O_{112}$, and $(si_{66}, r_{48}R_4)O_{112}$.

The variations in the calculated volumes of the tourmalines are greater than we have found in some other isomorphous species. Instead of taking the equivalent weight and greatest density of each variety, Rammelsberg has only calculated the volume of each group, from a mean of the equivalents and densities, a method which cannot be expected to give accurate results.

The following monoclinic crystals have been indicated by Mr. Dana, as isomorphous; borax, glauber-salt, spodumene, pyroxene, acmite and hornblende.*

The sulphates being bibasic, glauber salt is $S_2Na_2O_3$, 20HO= 322·4, which, with a density of 1·469, gives a volume of 219, or doubling the formula 438. Borax is $2BO_3$, NaO, 10HO, which multiplied by four gives with a density of 1·73, an equivalent volume of 441·6.

Spodumene is represented by $(\dot{N}a\frac{1}{8}\ \dot{L}i\frac{7}{8})_3\ \ddot{S}i_9 + 4\ddot{A}l\ddot{S}i_2$, which multiplied by two and expanded, becomes $si_{66}O_{66}(al_{24}Li_4Na_2)O_{30}$, with an equivalent weight of 1455·5 and a density of 3·18 giving a volume of 457. The formula of white pyroxene, diopside, is $si_{52}O_{52}(Ca_{13}Mg_{13})O_{26}$ which with a density of 3·24, gives also the volume 457. Hedenbergite belongs to the same type, and is $si_{52}O_{52}(Ca_{12}Fe_{12}Mg)O_{26}$ with a density of 3·5 and a volume of 462. The aluminous augite, hudsonite, is represented by $(si_{32}al_{16})O_{48}$, $(Fe_{16}Ca_7Mn)O_{24}$, and with a density of 3·46 gives a volume of 448. Wollastonite, a lime pyroxene, approximatively isomorphous with the above species, is $si_{44}O_{44}Ca_{22}O_{22}$, and with a density of 2·9 has a volume of 446·16.

In the different varieties of augite or pyroxene, the oxygen of the silica, or of the silica and alumina combined, is to the oxygen of the protoxyd bases as 2 : 1, while in the hornblendes the ratio is as 9 : 4. There are however many examples of minerals with the cleavage of pyroxene and the formula of hornblende, while there are hornblendes whose analyses give the augite ratio of 2 : 1. Carinthite with the form of a hornblende, pertains to the same type as hudsonite; Dana's formula equals† $(si_{24}al_4)O_{32}$, $(Fe_4Ca_3Mg_7)O_{14}$, with a density 3·127, and a volume of 258·3, which gives for the formula $(si_{11}al_7)O_{48}$, $(Fe_7Ca_5Mg_{12})O_{24}$ a volume of 442·8.

* This Journal, [2] vol. ix, p. 223, and p. 429, also vol. x, p. 119.

† This Journal, [2] vol. ix, p. 231.

Hornblende represented by $\dot{S}i_3\dot{M}g_3\dot{C}a$, has an equivalent of 227·74, which with a density 2·93, gives a volume of 77·7; multiplying by six, we have 466 as the volume of tremolite, with the formula $si_{54}O_{54}(Mg_{18}Ca_6)O_{24}$. The density above given is probably too low, for anthophyllite $si_{54}O_{54}$, $(Mg_{18}Fe_6)O_{24}$ with a density of 3·16 gives a volume of 447·2. Acmite belongs to the hornblende type, and is represented by $si_{54}O_{54}$, $(fe_{18}Na_6)O_{24}$, which with a density of 3·4, corresponds to a volume of 441.

For some important observations upon the association of augite and hornblende, and their intermixture with grains of chrysolite and chabazite, see Sandberger in Poggendorf's Annalen, vol. lxxxiii, p. 453.*

We subjoin in a tabular form, the formulas, densities and equivalents of the above species.

Species.	Formula.	Density.	Volume.
Glauber-salt,	$S_4Na_4O_{16}$, $H_{40}O_{40}$	1·469	438·
Borax,	$B_8Na_4O_{28}$, $H_{40}O_{40}$	1·730	441·6
Spodumene,	$si_{60}O_{60}$, $(al_{24}Li_4Na_2)O_{30}$	3·180	457·
Diopside,	$si_{52}O_{52}(Ca_{13}Mg_{13})O_{26}$	3·240	457·
Hedenbergite,	$si_{52}O_{52}(Ca_{12}Fe_{12}Mg)O_{26}$	3·500	462·
Hudsonite,	$(si_{28}al_{10})O_{48}$, $(Fe_{16}Ca_7Mn)O_{24}$	3·460	448·
Carinthite,	$(si_{41}al_7)O_{48}$, $(Fe_7Mg_{12}Ca_5)O_{24}$	3·127	442·8
Wollastonite,	$si_{44}O_{44}$, $Ca_{22}O_{22}$	2·900	446·1
Tremolite,	$si_{54}O_{54}$, $(Mg_{18}Ca_6)O_{24}$	2·930	466·
Anthophyllite,	$si_{54}O_{54}$, $(Mg_{18}Fe_6)O_{24}$	3·160	447·2
Acmite,	$si_{54}O_{54}$, $(fe_{18}Na_6)O_{24}$	3·400	441·

The formulas of spodumene, diopside, hudsonite, and wollastonite, are seen to be homologues of the first kind, and are represented by $n(si_2MO_3)$, the values of n being 30, 26, 24 and 22. The formula of diopside equals 78RO, which is equal to that of the hornblendes; if we admit that silica plays the same double part as alumina, the formula of hornblende may be written $si_{52}O_{52}$, $(si_2Mg_{18}Ca_6)O_{26}$ corresponding to diopside. In this way the formulas of the silicates may be finally reduced to homologues of the first kind, while homologies of the second kind, having regard to the distinction between silica and the bases, assume but a subordinate importance in the arrangement of allied genera.†

Dana, dividing the volume deduced from his formulas by the number of the atoms of elements, obtained quantities nearly iden-

* Cited in this Journal, [2] vol. xii, p. 389.

† Prof. E. J. Chapman, starting from the idea that Al_2O_3 replaces SiO_3, has extended the same view to other sesquioxyds, as Fe_2O_3, O_2Mn_3 etc., and thus refers Rammelsberg's crednerite $2Mn_2O_3$, 3(BaO, CuO) to the augite type $2SiO_3$, 3MO. Looking upon $3TiO_2$ as equivalent to $2SiO_3$, he reduces sphene and epidote to the same general formula. Two communications by him in the Philos. Mag. for 1852, vol. iii, pp. 141, and 270, contain many ingenious and important generalizations with regard to mineralogical classification.

tical for the pyroxenes and hornblendes, as well as for the tourmalines and many other groups of isomorphous species; the volumes thus obtained he has designated by C, the first being the A volumes.* If instead of taking the A volume, we divide the gross equivalent weights by the number of atoms, we obtain the mean equivalent weight of these atoms, and it is clear that C represents only the volume corresponding to the atoms in these isomorphous species, where the condensation is alike. The equivalent weight of silica SiO_3 is 46·22; this divided by four the number of atoms according to Mr. Dana's notation, gives 11·55; in the same way $Al_2O_3 = 51·4 \div 5 = 10·3$; $MgO = 20·36 \div 2 = 10·18$; $CaO = 28· \div 2 = 14·$ etc.; so that in formulas made up of varying proportions of these elements, the mean equivalent weight will be nearly the same, and in isomorphous species where the density varies as the gross equivalent, the C volume will only vary as the mean equivalent. But if elements of a higher equivalent weight are introduced into the formula, the C volume is at once changed, although if the new species belong to the same crystalline type, a relation will be apparent in the A volume, to which alone any real value belongs.

The similarity in crystallization between species whose formulas differ only in the elements of water, has been pointed out by Laurent in certain salts of organic acids, and is seen in several mineral species. The chabazites, for example, give the formula $\dot{R}_3\,\ddot{S}i_4,\ 3\ddot{A}l\,\ddot{S}i_2$, with 15$\dot{H}$ and 18$\dot{H}$, while the variety ledererite of Jackson, affords according to Hayes and Rammelsberg, but 6$\dot{H}$† The hydrous iolites are also cases in point, as well as aspasiolite, the serpentines, and the talcs with their varying proportions of water. In the formulas of these species, water appears to replace magnesia, and Scheerer has shown that many different species may be referred to a common chemical type, by admitting 3HO to replace MgO, and 2HO to replace CuO, etc.‡ These cases to which he has given the name of polymeric isomorphism, are instances of the partial substitution of water for other bases, in homologous genera which differ by n MO.

He has shown from the analyses of a great number of talcose minerals, affording from four to nine per cent. of water, that by assuming 3HO to be equal to MgO, or in other words by adding to the oxygen of the magnesian and other earthy bases, that of one-third of the water, the ratio of the sum is to the oxygen of the silica, as 4 : 9, which is that of hornblende, 24 : 54. In certain foliated talcs, the ratios of the oxygen of the silica, bases and water, are as 15 : 6 : 2.—15 : $6\frac{2}{3}$: : 9 : 4, and 15 : 8 : : 54 : 28 nearly,

* This Journal, [2] vol. ix, pp. 221 and 407, and xii, p. 204.

† See this Journal, vol. xv. p. 230.

‡ Poggendorf's Annal., vol. lxviii, p. 319, and lxxxiv, p. 321, also this Journal, vol. v. p. 381, and xiv, p. 37.

so that the formula becomes $si_{54}O_{54}(M_{21}H_7)O_{28}=82RO$, while some amorphous talcs give $si_{54}O_{54}(M_{19}H_{15})O_{24}=88RO$, or the formula of hornblende, plus 4MO and 10MO.

A talc-diallage from Presnitz affording 6·5 per cent. of water, gives according to Scheerer's view, the relation of augite, or 2 : 1; but if the water be excluded, we obtain the relation of hornblende or 9 : 4, and with the water, the formula is nearly $si_{54}O_{54}(M_{24}H_3)O_{32}=86RO$; a similar relation appears in the nephrites which Scheerer has referred to the augite type. In certain other hydrous magnesian minerals, affording from five to ten per cent. of alumina, he has endeavored to show that $3Al_2O_3$ replace $2Si O_2$, and thus deduces for the various species, between the oxygen of the silica, with that of two-thirds of the alumina, and the oxygens of the protoxyds with that of one-third of the water, a ratio of 2 : 1. But it will be found that his analyses admit of a simpler interpretation; if we conceive al O to replace si O, as in hudsonite and carinthite, we obtain, for all the aluminous species which he has referred to the augite type, (with but one exception,) a ratio between the sum of the oxygen of the silica and alumina on the one hand, and the oxygen of the protoxyd bases on the other, (that of the water being excluded,) of 9 : 4, while the oxygen of the water is equal either to 1 or 2, so that the formulas may be written $(si\ al)_{54}O_{54}$, $M_{24}O_{24}$ *plus* 6HO, and 12HO, = 84RO and 90RO. A diopside from Reichenstein affording 1·10 of alumina and 1·9 of water, is the exception referred to, and is an aluminous augite, *plus* water.

Without having considered the densities of these minerals, we give the above formulas as representing the general type, although perhaps not the real equivalents of the species.

We now proceed to examine a number of isomorphous species, some of which will serve to illustrate the question of hydrous silicates. The arragonite group and the species which Rose has compared with it, crystallize in right rhombric prisms, in which the angle M : M varies from 112° 6′ in bournonite to 119° in nitre. Mr. Dana has pointed out another isomorphous trimetric group, having for the same prism 119°–120°. They are epsom-salt, chrysolite, picrosmine, serpentine, villarsite, and chrysoberyl, to which last he has compared the crystallization of topaz. We add iolite and aspasiolite, without knowing any determination of the vertical axes of these species.

Epsom-salt is generally written SO_3, MgO, 7HO, and with a density of 1·689 (P. and Joule) gives 73·3 for its equivalent volume; the formula $S_7Mg_7O_{28}$, 49HO, will then correspond to a volume of 513, while the higher density 1·75 which has been assigned to it gives 492. The formula of chrysolite $(\dot{M}g\ \dot{F}e)_2\ \ddot{S}i$, may be multiplied by four, and the analyses of many specimens then lead to the formula $si_{48}O_{48}(Mg_{43}Fe_5)O_{48}$, which gives

with a density of 3·5, 512·8 for the equivalent volume. Picrosmine, $2(\dot{M}g^3\ddot{S}i^2)+3HO$ corresponds to the formula $si_{12}O_{18}(Mg_{24}H_{12})O_{36}$, differing from chrysolite by 12MO, and gives with a density of 2·68 a volume of 500·4. Serpentine, $2\dot{M}g_3\ddot{S}i_2, 3\dot{M}gH$, multiplied by three becomes $si_{36}O_{36}(Mg_{27}H_{18})O_{45}$, which with a density of 2·55 gives 496·5 for the volume. Villarsite, $4\dot{M}_3\ddot{S}i+3\dot{H}$ becomes $si_{36}O_{36}(Mg_{33}Fe_2MnH_9)O_{45}$, and with the assigned density of 2·975 gives a volume of 475·8.

Chrysoberyl, $\dot{B}e\ddot{A}l=(Beal_2)O_4$, which with an equivalent weight of 63·98 and a density of 3·8, has a volume of 16·8; the formula $(Be_{30}al_{60})O_{120}$ gives a volume of 504. Topaz is represented, according to Forchammer, by $5\ddot{A}l\ddot{S}i+2\dot{A}lF_3=(si_{15}al_{15})O_{30}+al_6F_6$. If we look upon fluorine as replacing oxygen, and raise the formula to $(si_{40}al_{56})O_{90}F_{16}=96RO$, the equivalent becomes 1748·5, which with a density of 3·65 gives a volume of 479; a colorless transparent Brazilian topaz gave me however a density of 3·57 which corresponds to a volume of 490. Andalusite is approximatively isomorphous with topaz; the formula $\ddot{A}l_3\ddot{S}i_2=(al_9si_6)O_{45}$; making it $(si_{40}al_{60})O_{100}$, we have with a density of 3·2, a volume of 497·8. The results of some analyses give the proportions of si to al, as 44 : 56, showing a partial replacement like that observed in some pyroxenes, and in the varieties of staurotide and kyanite, a consideration of whose volume and equivalents we reserve for another occasion.

The formula of iolite according to recent analyses by Scheerer, may be written $si_{45}O_{45}(al_{27}Mg_9)O_{36}$; the magnesia being sometimes in part replaced by protoxyd of iron; with (Mg_7Fe_2) and a density of 2·66, we have 515 for its equivalent volume, while the aspasiolite of Scheerer* is exactly represented by $si_{45}O_{45}(al_{27}Mg_{5\cdot5}FeH_{10\cdot5})O_{44}$, with a density of 2·764 and a volume of 506. The formulas ascribed to chlorophyllite, esmarkite and fahlunite, represent these species as iolite *plus* water, and when compared with that species are as follows:

Chlorophyllite, . .	$si_{45}O_{45}(r_{27}R_9H_6)O_{42}$.
Esmarkite, . . .	$si_{45}O_{45}(r_{27}R_9H_9)O_{45}$.
Fahlunite, . . .	$si_{45}O_{45}(r_{27}R_9H_{18})O_{54}$.

The densities of these minerals vary from 2·7 to 2·9, so that their volumes will be near to that of aspasiolite; esmarkite may probably belong to the same type with that species. From the analyses of iolite it appears that it generally loses from 1 to 1·5 per cent. by ignition, and is perhaps never entirely anhydrous.

The volumes and equivalents of the above species are as follows:—

* Pogg. Annal., vol. lxviii, p. 319, and this Journal, vol. v, p. 381.

		Density.	Volume.
Epsom salt,	$S_7Mg_7O_{28}, H_{49}O_{49}$	1·750	492·
Chrysoberyl,	$(Be_{30}al_{30})O_{120}$	3·800	504·
Andalusite,	$(si_{40}al_{60})O_{100}$	3·300	497·8
Topaz,	$(si_{40}al_{56})O_{80}F_{16}$	3·570	490·
Chrysolite,	$si_{48}O_{48}(Mg_{43}Fe_5)O_{48}$	3·500	512·8
Picrosmine,	$si_{48}O_{48}(Mg_{24}H_{12})O_{36}$	2·680	500·4
Serpentine,	$si_{36}O_{36}(Mg_{27}H_{18})O_{45}$	2·550	496·5
Villarsite,	$si_{36}O_{36}(Mg_{33}Fe_2MnH_9)O_{45}$	2·975	475·8
Iolite,	$si_{45}O_{45}(al_{27}Mg_7Fe_2)O_{36}$	2·660	515·
Aspasiolite,	$si_{45}O_{45}(al_{27}Mg_{5·5}FeH_{10·5})O_{44}$	2·764	506·

Scheerer in the paper last cited, has shown that iolite and aspasiolite not only crystallize alike, but are even associated in the same crystal, one species passing into the other, and the iolite or cordierite often forming the central portions of the crystal. The formation of the hydrous species from an alteration of iolite, requires an agency which should at once remove magnesia and supply water; Scheerer from the characters of the accompanying minerals, rejects the idea of such a change, and seems to regard the association as an instance of the crystallizing together of two isomorphous species. He then alludes to the large crystals of serpentine which occur imbedded in solid ilmenite or crystalline magnesite, and associated with mica, in the gneiss of Snarum in Norway, and concludes from the absence of any appearance of change in the associated minerals, that these crystals of serpentine cannot have resulted from an alteration of chrysolite. This serpentine afforded Scheerer an amount of water corresponding to the formula given above, but G. Rose has lately described crystals from this locality which have a centre of unaltered chrysolite; one of them gave on analysis 53· per cent. of magnesia and only 4· of water, corresponding according to him to a mixture of the two species. He hence in opposition to Scheerer, Tamnau and Böbert who have examined the locality, regards these, and indeed all crystals of serpentine and the related species, as pseudomorphous.*

A glance at the formulas given above, will suggest an objection to this view. Chrysolite might be converted into picrosmine, by removing one-half of the magnesia, and partly replacing it by water, for the silica in equal volumes is the same. But if a conversion into serpentine is supposed to be effected by adding water, and removing a portion of oxyd of iron and magnesia, the 48 si O of an equivalent of chrysolite will make one and one-third equivalents of serpentine, and the volumes of the two species will be 512·8 : 662·0, or since the volumes of equivalents are theoretically identical, as 3 : 4. But neither in the magnesite and ilmenite which enclose the serpentine of Snarum, nor in any localities of crys-

* Monatsber. Berl. Akad., cited in this Jour., vol. xii, [2] p. 315.

tallized serpentines or of interstratified masses of this mineral, as far as I am aware, have there been observed any marks of the disruption, displacement, and other mechanical effects which should result from such a great increase in volume.

The advocates of this hypothesis as to the origin of serpentine, will scarcely maintain that the action in this case is different from that which should produce aspasiolite from iolite, or imagine a removal of both silica and magnesia from part of a crystal of chrysolite, while the surrounding silicates and carbonate of magnesia are like the remainder of the crystal, unaltered. The generally admitted notions of pseudomorphism seem to have originated in a too exclusive plutonism, and require such varied hypotheses to explain the different cases, that we are led to search for some more simple explanation, and to find it in many instances, in the association and crystallizing together of homologous and isomorphous species.

We have in these pages given the first series of illustrations of our views respecting the homologies of chemical formulas, and the similarity of volume in isomorphous species; it is believed that these views will be found to enlarge and simplify the plan of chemical science, and lead to a correct mineralogical system.

Montreal, Canada, June 21st, 1853.

ART. XXIII.—*Theoretic Determination of the Expenditure of Heat in the Hot-air Engine;* by F. A. P. BARNARD, Professor of Chemistry and Natural History, in the University of Alabama.

So much has been vaguely and variously said of late, in the magazines and journals of the day, in regard to the economy of heat which is claimed to be one of the great merits of the engine invented by Captain Ericsson, as to render an examination of the question, what is the true expenditure required to keep up the action of the engine, worth attempting. The confusion of thought which appears to prevail on the subject, is probably in a great degree owing to the fact, that the theory of heat, in its relations to force, has recently undergone a great and important change; so that men, who argue from its doctrines as taught twenty years ago, are liable to commit the most serious errors.

According to the theory then received, power was regarded as an accidental concomitant of heat, and not as a tax upon it. It was therefore believed that air which has undergone expansion by heat, while under a constant pressure, retains, at the end of the time, all the heat which has been imparted to it during the expansion. It would follow as a corrollary, that, if such air could

be passed through a contrivance for accomplishing *perfectly* the purpose for which Ericsson's regenerators are intended, it would deposit there all the heat it had received. And if, as is the case with the Ericsson engines, the contrivance should fall short of being perfect, in so far that the escaping air should be sensibly warmer than it originally was, the thermometer might be appealed to as a just measure of the amount of heat lost. Captain Ericsson has been understood by most persons to hold this doctrine; whether justly or not, the present writer, having met with nothing on the subject published with his explicit sanction, is unable to say.* Whatever may be his own views, however, reporters who have heard him and friends who speak for him, have so expressed themselves, as to leave no doubt that they so understand him. To such persons a curious practical paradox may be proposed, for which they would find it difficult to account, as follows:

Suppose an engine to be constructed on Ericsson's plan; but with a supply of cylinder equal to the working cylinder. Suppose, furthermore, that the condensed air, on its way from the supply cylinder to the working cylinder, should be made to pass through a refrigerator, which we will also suppose to have the power to do its work so effectually, that the air, at the moment of entering the regenerator from the reservoir, shall be reduced in temperature to a perfect equality with the surrounding atmosphere. In addition to this, we will suppose that the regenerators have power to effect perfectly the object for which they are intended; that is, to impart to the air the maximum temperature employed in working the engine, and to absorb from the same air, as it escapes, all the sensible heat it holds, above the temperature of the external air. Finally, we will make such other suppositions as are usual in theoretic abstractions, viz., that losses and drawbacks from accidental causes, (in this case, losses by radiation and conduction, or by leakage of the heated air,) are all zero. The working and supply cylinders being equal, it is manifest that the initial and final densities of the air must be equal also.

Now, at the completion of the stroke, the cylinder will be full of air of density $=1$ and temperature, say 450° F. above that of melting ice, or 32°. This air, being permitted to escape through the regenerator, returns to the atmosphere at density $=1$,† as before, but at the temperature of the weather, say 60° F., or 28° above melting ice; having left the difference $=422°$ in the regenerator. The persons who apparently speak for Capt. Ericsson

* Since this was written, an article by Capt. Ericsson, published in Appleton's Mechanics' Magazine for June, has come under the eye of the writer. It leaves no doubt that Capt. Ericsson's views have been correctly represented in the publications which have heretofore been made, on his behalf, though not avowedly by his authority.

† It is usual to put 1 = density at 32°, under pressure of 30 inches of mercury. For our present purposes, it is more convenient to make the density at 60° = unity, modifying the co-efficient of expansion, as explained further on.

on this subject, would of course expect that the next charge of air from the reservoir, taking up these 422°, would, in like manner as the former, lift the piston completely up, exerting precisely the same pressure as before, and filling the cylinder once more with air at the temperature of 450°. And they would expect to see this operation again and again repeated; so that, accidental losses being excluded by the supposition, the furnace would be unnecessay. And indeed, the only use of the furnace in the *practical* case, would, in their view, be, to repair the waste of heat resulting from imperfect insulation, from leakage, and from the necessary incompleteness of transfer in the regenerator. Such persons would therefore be probably surprised to find, that the second charge would not maintain the temperature of 450° to the end of the stroke, that the third charge would fall off in temperature still more than the second, and so on till the regenerator should be completely cooled down. But what would perhaps occasion even greater surprise than this, would be the fact, that, if a second charge of air should be drawn through the same regenerator not from the reservoir, but *from the supply cylinder directly*, the machine not now being self-acting, but being moved by some external force, this second charge, at the end of the stroke *would* have the full temperature of 450°, and (the other suppositions remaining,) would, in escaping, deposit its 422° of acquired heat in the regenerator; which would again heat the next charge to 450°, and so on *ad infinitum*. To this paradox the old philosophy furnished no key. The initial and final densities and bulks of the air in both cases are identical; and in both cases the same amount of matter is exposed for the same time to the same source of heat. But the second process is attended with no diminution of the stock of heat originally supposed to be in the regenerator, while the first is rapidly exhaustive. How shall the difference be accounted for?

An apology may perhaps be due to many of the readers of this journal for occupying space with an explanation which few of them require. Still there are no doubt some whom such an explanation will gratify, and this is the reason for presenting one, in a concise form, here.

The specific heat of gaseous bodies is not the same when they are allowed to expand under an unvarying pressure, and when confined to a constant bulk. That is to say, it requires a larger amount of caloric (measured by consumption of fuel, or in any other proper mode) applied to a given mass of air, to cause it to affect a thermometer to a definite extent, (say 1°,) when free to expand, as in a cylinder closed by an air-tight piston without friction, and when prevented from expanding, as in a similar cylinder, the piston being immoveable. Mr. Regnault has, moreover, recently proved, in contradiction to the previously received opinion, that the specific heat of air, whether at constant pressure

or at constant volume, is the same for all densities between 1 and 10; and for all temperatures between − 30° and + 225°, centigrade (−22° and +437° F.);* so that, for all the purposes of this inquiry, we may regard this element as invariable, even if it should not prove to be so under all possible circumstances.

Now, in the case presented in our paradox, the air, at the end of the stroke, is under a pressure easily determinable by the following formula,

$$p' = p(1+\alpha\theta)\varrho,$$

In which p' represents the pressure sought, p the normal atmospheric pressure, 15 lbs. per sq. inch, θ = the temperature above melting ice, in degrees Fah., ϱ = the density of the atmospheric air at the time, and $\alpha = \frac{1}{491}$ (the co-efficient of expansion per degree F., according to Regnault, to be applied to the volume at 32° F.) If, to simplify the matter, we make $\varrho = 1$, then α will become at the assumed weather temperature of 60° F. = $\frac{1}{519} = \frac{1}{491+28}$; and θ must be reckoned from 60° upwards, instead of from 32°. Its value at the end of the stroke, according to our former assumption, is 422°. Hence $p' = 27{\cdot}2$ lbs. per sq. inch, or 1·813 atmospheres.

But, as the air of the reservoir, at the temperature of 60°, when $\theta = 0$, has the same elastic force, its *density* must, by the same formula, be now = 1·813. From this density to density 1, therefore, it is expanded by 422° of heat, under constant pressure. Now the ratio of the specific heat of air at constant pressure to that at constant volume, is, acccording to a mean of values given by Poisson, about 1·36.† If therefore the air had been heated

* Comptes Rendus, Apr. 18, 1853.

† This is the mean, or about the mean, of two values given by Poisson. But Poisson gives also 1·421, as a value determined by Dulong for air perfectly dry, and he also gives 1·4061, as a value determined by direct observation on the velocity of sound, by the commissioners of the French Bureau of longitude.

Major Barnard, in an article published in Appleton's Mechanics' Magazine, for July, and received since the present article was prepared, adopts the value 1·324, determined experimentally by Mr. Petrie. On the other hand, Mr. Rankine in the Lond. Phil. Mag., for June, and supplement for the same month, gives 1·40, and 1·41, as the limits which contain the true value, and 1·4094 as the value determined by observation on the velocity of sound. Poisson inclines to the largest of all the values, (1·421), on the ground that observations on sound, are liable to give the value too small, in consequence of fluctuations in the quantity of heat contained in the air undergoing compression and dilatation.

With the increase of γ, both the positive and the negative terms of pressure in the air engine are increased; but the advantage is on the whole on the positive side. Thus, if we adopt 1·324, instead of 1·36, we lose above 7 per cent. of *available* power —that is, power over and above resistance. If we adopt 1·4094, we shall gain nearly 11 per cent. of available power. The value first introduced into the text is allowed to stand, though perhaps the weight of authority is in favor of a higher number.

The foregoing observations (as to the effect of a variation of γ upon working power) are however founded on the supposition that the mechanical equivalent of a unit of

without enlargement of bulk, the same amount of caloric would have raised its temperature as much more than 422°, as 1·36 is greater than 1, that is, 573°·92. But as, at the end of the stroke its temperature is but 422° above that of the weather, it can give up only the 422° as it escapes. The difference =151°·92 has apparently been annihilated; but it has actually been converted into expansive power, and is irrecoverable.

In saying that it is irrecoverable, however, nothing more is meant than that it is utterly lost to any useful mechanical purpose. But, by undoing the work which this heat has done, that is, by forcing down the piston upon the confined air until we have expanded as much labor as has been accomplished by it—we may elevate the temperature by an amount corresponding to the seeming loss. It is hardly necessary to say, that this amount of heat will be developed, before the density shall have been reduced to that of the reservoir, 1·813, because the pressure in this reverse stroke is not constant, but rapidly rises, on account not only of the increase of density, but because of the developed heat itself.

In this case there is a seeming as if we recovered the 151°·92 degrees of heat which on our supposition had been imparted to the air by the regenerator, and had become insensible. But had the cylinder been filled with air from the atmosphere, and not from the reservoir, and had this air at density 1, been heated 422° as before, it would still yield to the same compression, precisely as large an increment of heat, as in the other case; although, this time, it would have absorbed in truth only the 422° which it seemed to absorb. The fact is, that, in both cases, the rise of temperature is an effect of labor converted into heat; as in the first case, heat is converted into labor.

We can easily understand, now, why, if a charge of air be supposed to pass through the regenerator into the working cylinder, directly from the (equal) supply cylinder, the whole amount of

heat is an invariable quantity, independent of the form of matter through which it is exerted; and, in elastic fluids, independent of the ratio between the two specific heats. A consideration of Poisson's formula (1) nevertheless shows that, p' and p being taken constant, and ϱ made =1, the value of ϑ' will be greater as γ is less. And in the general formula,

$$p'=p(1+\alpha\vartheta)\varrho$$

It is evident that, p' and p being constant, as before, ϑ must be less as ϱ is greater. But the labor of compression, by which p is raised to p', will be greater as ϱ is greater, that is, as γ is less. Hence, to assume that γ is less is to assume implicitly that a greater amount of labor is represented by a less amount of developed heat; or, to vary γ is to vary the mechanical equivalent of a unit of heat applied to air. This consideration more than countervails the former, and leads to the theoretical result, that to diminish γ is rather to increase than diminish the working power, while it does really diminish the number of units of heat converted into labor.

And from this, we may further add, it incidentally appears, that an accurate experimental determination of the mechanical equivalent of a unit of heat applied to air, may lead, through Poisson's formulæ, directly to the true value of γ; and *v. v.*, that a correct independent determination of γ, should furnish, through the same, the true mechanical equivalent of heat.

heat which it receives will be faithfully returned again as it escapes. It is now heated without undergoing enlargement of bulk, and it absorbs neither more nor less heat than the denser charge would absorb, were it heated just as many degrees by the thermometer, without being permitted to expand—without being allowed, that is, to do any work, for heat, it is now well settled, will no more perform its labor *gratis*, than any other known power.

The expenditure of heat, therefore, absolutely necessary to the working of one of Ericsson's engines, in which the supply and working cylinders are equal, and no cut-off is used, in which no heat is consumed but in working, and in which the air is cooled, between the supply and working cylinders, down to the weather temperature, assumed at 60° F., will be in a general expression,

$$(T - \theta)(\gamma - 1)\,MK_v \qquad (I)$$

In which T is the temperature of the air in the working cylinder, θ, that of the weather, γ, the ratio of the specific heat of air at constant pressure to that at constant volume, M the mass of air heated; and K_v, the symbol employed by Mr. Rankine to express the mechanical equivalent of the specific heat of air at constant volume.*

But as, in point of fact, the temperature of the reservoir is not kept down to that of the weather, but is a value, say θ', due to compression in the supply cylinder, so the change of temperature in passing into the working cylinder is less; being $T - \theta'$, instead of $T - \theta$. Hence, the heat expended in working will be really, expressed in mechanical equivalents,

$$(T - \theta')(\gamma - 1)\,MK_v \qquad (II)$$

An engine of this kind would be immensely powerful, but for the fact that a large amount of the heat which it thus consumes is employed in compressing air to feed itself. If the compressed air were allowed to expand against the piston, without receiving any additional heat, it is capable of exerting precisely as much power as has been employed in compressing it; so that, if this power could be all effectually applied, it would be just adequate to the compression of a new charge, and both power and resistance might be accounted zero. But it must not hence be inferred that all the heat derived from the furnace, and consumed in working, is therefore converted into available power; for just in proportion as the air remains heated above the temperature of the weather, at the close of the stroke, in the same proportion it is impossible for the heat developed by compression to reëxpend itself in expansion; and to that extent it must prove a dead loss, unless it can be saved by the regenerator.

* We refer this symbol here, however, to the degree Fah., and not the degree centigrade.

But the temperature of the regenerator can never be lower than that of the blast which cools it, that is to say, of the air of the reservoir. And hence it follows, as a necessity of the case, that the heat of compression must be unavailable; and that the furnace must furnish the power necessary to compress the air, as well as to do the work of the engine. The amount of heat thus unprofitably spent, depends on the degree of compression which the air has undergone, which last is determinable by the following formula of Poisson:

$$(p' = p \left(\frac{\varrho'}{\varrho}\right)^{\gamma} \qquad (1)$$

In which p', p, ϱ and γ are used as before; and ϱ' is the density due to the compression. In the present case, ϱ' is found to be $=1{\cdot}5489=1{\cdot}55$ nearly.

The temperature of the compressed air is determined by the following, in which it is represented by θ', Θ being the number of degrees required to double the volume, at 32° original temperature.

$$\theta' = (\Theta+\theta)\left(\frac{\varrho'}{\varrho}\right)^{\gamma-1} - \Theta \qquad (2)$$

Putting $\Theta=491$, according to Regnault, we shall have $\theta'=116°{\cdot}54$ $=88°{\cdot}54$ above the original temperature. To this extent, therefore, the regenerator must fail, even if supposed perfect, to absorb the 422° of sensible heat which the air contains at the end of the stroke. The difference, 333°·46, is the limit of possible economy to be secured by the use of this contrivance. Now expression (II) with the substitution of the value of θ' here obtained, gives us, as the total amount of heat converted into power,

$$120{\cdot}0456\ \mathrm{MK_v}$$

of which, is balanced by the waste heat developed by unavailable labor,

$$88{\cdot}54\ \mathrm{MK_v}$$

reducing the mechanical power actually developed to an available amount of

$$31{\cdot}5\ \mathrm{MK_v}.$$

But, as this waste is unavoidable, we are obliged, in instituting a comparison between the power necessarily expended, and the effect produced, to regard the engine as debtor to the entire amount of 120 $\mathrm{MK_v}$, while we credit it with the available power as computed by the formulæ laid down in another article in this Journal.

Now $$120{\cdot}0456\ \mathrm{MK_v} = 88{\cdot}2688\ \mathrm{MK_p},$$

in which $\mathrm{K_p}$ is the mechanical equivalent of the specific heat of air at constant pressure. And, as ·2376 is (according to Regnault's most recent determination) the specific heat of air at constant pressure, that of water being taken as unity,

$$88{\cdot}2688 \times {\cdot}2376 = 20{\cdot}97\ \mathrm{MK_w}$$

expresses the positive power developed by the engine in mechanical equivalents of the specific heat of water. In other words,

every pound of air receives an amount of heat which it does not afterward restore, sufficient to raise the temperature of a pound of water 20°·97 F. But a cylinder 22100 sq. inches base and 72 inches altitude, will contain about 70 lbs. of air of ordinary density. Hence, the unavoidable expenditure of heat at every stroke of a hot air engine, having such a supply as well as working cylinder, and working without cut-off, will be $=20°·97\times70$ applied to one pound of water $=1470°$, nearly.

To convert water into steam at 212° requires, at the usual estimate, 1142°. And $\frac{1470}{1142}=1·287$ lbs. According to Bourne's tables, the mechanical effect of one cubic inch of water converted into steam at 212°, is equal to 2083 pounds raised one foot. And 1·287 lbs. = 35·58 cubic inches, similarly converted into steam at 212°, are equivalent to 74100 pounds raised one foot, or 12075 pounds raised through a six foot stroke. But we have seen in the article already mentioned, that the effect of a hot air engine, with supply and working cylinders equal, and pistons of 22100 sq. inches, is equal to 56400 lbs. during the stroke. The advantage is in favor of the heated air, to the extent of 1 : 4·63.*

If we take the properties of Ericsson's engines—that is, make the supply cylinder two-thirds of the working cylinder in capacity, we shall have, provided we put the cut-off at two-thirds the stroke, for every unit of weight of the air employed, the same number of units of heat, as before, at the moment of cut-off; but, in consequence of the subsequent expansion, there will be an ad-

* Capt. Ericsson, in his article alluded to in a previous note, expresses great contempt for the absurdity of the idea of employing supply cylinders equal to the working cylinders. But the reason assigned by him in proof of the absurdity is a little curious. He says that, in this way, something more than 1000 horse power is thrown away, by turning the air adrift while at the pressure of 12 pounds above the atmosphere, "*after that pressure had been obtained at the expenditure of force and fuel.*" Now, if the regenerator is capable of taking back the heat still unconsumed at the end of the stroke, it is a benefit, though Captain Ericsson cannot see it, to "turn the air adrift" at the highest possible pressure; or, in other words, to carry the maximum pressure to the end of the stroke: and the comparison which presently follows above, sufficiently shows, that, by so doing, the power developed is greater in proportion to the heat consumed, than when a less supply is used and the air is worked expansively. But in Capt. Ericsson's engines, the absurdity of a supply equal to the working cylinder, consists in the fact, that the effective power is absolutely zero throughout nearly two-thirds of the stroke, though working without cut-off; and that a cut-off creates a negative pressure at the close of the stroke, when the mate engine is itself powerless or worse. These difficulties are removed by the plan recommended in another article of the present writer in this Journal.

The absurdity discovered by Captain Ericsson is one of his own invention. He speaks of heated air precisely as if it were so much steam. And because steam cannot be turned adrift without carrying with it all its heat, he quite forgets his regenerators, and the purpose for which they are intended. His error, is explained, however, the moment we recognize his more radical theoretic error, viz: that the elastic force in air which is due to density, is something so independent of heat, though varying with temperature, that *it may be worked off without any expenditure of heat at all.*

ditional consumption of heat, with corresponding depression of temperature. The expression,

$$120{\cdot}0456\ \mathrm{MK}_v = 20{\cdot}97\ \mathrm{MK}_w,$$

M being equal to 47 lbs. instead of 70, will give us only 986° F. applied to one pound of water. But the subsequent expansion, according to Poisson's formula, (2,) will give a temperature of 322° at the end of the stroke, which is a falling off of 128, from the maximum, 450°. This is converted into mechanical effect, and this the regenerator cannot save.*

$$128\ \mathrm{MK}_v = 94{\cdot}44\ \mathrm{MK}_p = 22{\cdot}44\ \mathrm{MK}_w.$$

Hence, owing to the expansion after cut-off, there is an additional consumption of heat at every stroke sufficient to raise the temperature of a pound of water, $22°{\cdot}44 \times 47 = 1054°{\cdot}68$. This amount added to the former gives 2040°·68. But $\frac{2040{\cdot}68}{1142} = 1{\cdot}787$ lbs. of water $= 49{\cdot}41$ cubic inches, which, converted into steam at 212°, is adequate to raise 102914 lbs. one foot, or 17152 pounds through the six foot stroke. But we have seen that the power of the hot air engine, of the proportions and dimensions supposed, is represented by 74698 pounds raised through the same distance, which makes the advantage in favor of air, as 1 : 4·35. If we allow to the steam the benefit of the same amount of expansion, its effect will be (assuming γ for steam to be the same as for air,) equal to 23050 lbs. during the stroke,† reducing the foregoing ratio to 1 : 3·24.

But it has been shown, in the article before alluded to, that these are not the proportions most favorable to the efficiency of the air engine. If $1 : m$ represent the ratio of capacities of working and supply cylinder, and $1 : l$ be the ratio of the full stroke to the fractional part up to cut-off, then $\frac{m}{l}$ should be greater than unity.

This proposition will, however, be understood to be asserted only in reference to the theoretic consumption of heat, as compared with the power developed, and to the amount of available power to be obtained from a working cylinder of definite dimensions. It is entirely independent of the question as to what volume of air can be heated by the furnace and regenerators, so as

* Capt. Ericsson says that the furnace will prevent this depression of temperature. If it does, (which is no doubt impossible, however,) the power of the engine will be greater, but the expenditure of heat will be greater also. In the present case, it will amount to 174°, instead of 128°. It would be folly, however, to introduce the former number into the calculation, since the maximum temperature cannot possibly be sustained during the expansion. The furnaces may, nevertheless, somewhat check the depression.

† Determined by the method given in a following article, and not by the imperfect modes commonly employed by engineers.

to give the best velocity to the piston. For it will be obvious that, though the theoretical consumption of heat is less when $m=1$, than when it is less, as $\frac{2}{3}$, yet the volume of air which must be heated and cooled at every stroke is fifty per cent. greater in the former case than in the latter. Moreover, since the theoretic estimate of consumption is founded on the supposition that the regenerators fulfill their function perfectly, the practical loss of heat arising out of the imperfection of their action will be just as much greater in the first case than in the second, as the supply cylinder is larger. If there were no waste at all from this cause, then condensing cylinders of large dimensions, with supply cylinders to throw the air into the reservoir *after* condensation, as described in the following article already referred to more than once, and with $l<1$, would furnish engines much more powerful than those of Ericsson, both absolutely and with relation to the consumption of heat.

It is no part of the present purpose to investigate the question, what would be the best theoretical proportions of the cylinders to each other, and of the cut-off to the stroke; or the numerical ratio of $l:m$, which would render the largest amount of heat available. The results of such an enquiry must always be subordinate to the experimental determination of the power of the regenerators, and the amount of waste arising from their imperfect absorption of the heat of the escaping air. In these particulars, a variation of the volume of air employed, may introduce differences which theory cannot anticipate. Leakage, moreover, may possibly be dependent, in some measure, upon the relative proportions of the cylinders. But losses from radiation, conduction, and by escape through the smoke-pipes, will not be materially different, so long as the working cylinder remains invariable in size, whatever be the magnitude of the supply cylinder.

Upon the whole, it cannot be denied that the results of theory are, in one important point of view, favorable to the hot air engine. The available power developed in this machine ought to bear a much larger ratio to the mechanical equivalent of the heat expended, than is true of the steam-engine, even when steam is worked with large expansion. But, in another point of view, the air engine is yet, even in theory, far behind the steam-engine; since, though it lays out the heat to advantage, it requires a very bulky and ponderous apparatus *to lay out the amount of heat* necessary for the creation of great power. Whether there is any escape from this difficulty is more than doubtful; but whether the evil may not be so far reduced as to render the engine an eligible motor on the ocean, for commercial purposes, if not for high speed, is a question which we are not yet justified in answering in the negative.

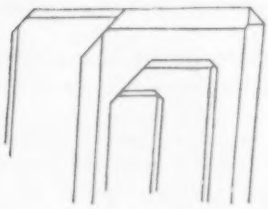
University of Alabama, July 7, 1853.

Art. XXIV.—*On the occurrence of Crystallized Carbonate of Lanthanum;* by W. P. Blake.

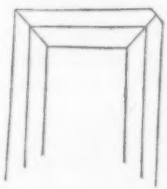
The mineral I am about to describe was found near Bethlehem, in Lehigh Co., Pa., associated with the zinc ores of the Saucon Valley. It was thrown out from a few feet below the surface, by the miners when sinking an exploring shaft near one of the veins of calamine in limestone. A single specimen of the mineral was preserved by Dr. W. W. Dickenson the superintendent, who at my request furnished me with a part of it for examination. The specimen was about three inches in diameter and attracted my attention by its delicate pink color and peculiar structure, being an aggregation of thin plates and scales of a pearly luster, forming a light reticulated mass which was found to be highly crystalline on examination by a glass, and the crystals were apparently rectangular in form. A more satisfactory examination of them was made by placing some loose fragments upon the stage of a microscope, and viewing them with a glass of moderate magnifying power. The appearance in the field of the instrument was beautiful and exceedingly interesting, each minute fragment being a part of a well formed tabular crystal, and retaining many of its edges and angles. It became evident that the angles formed by the meeting of the principal edges were oblique. Each large crystalline plate had upon its broad surface one or more smaller crystals.

Two of the forms observed are here represented.

1.



2.



The edges of all the crystals appeared to be beveled, and one or two were seen on which there was a double bevelment as represented in the second figure.

The crystals were so very thin that it was not possible to measure the inclinations of these planes.

I however obtained the angles of the tables by the aid of the rotating eye-piece micrometer attached to Nachet's large microscope. The crystal gave the angles 94° and 86°.

The measurements were repeated upon several crystals in different parts of the field with uniform results, as here given.

	I.	II.	III.	IV.	V.
Obtuse,	93° 30′	93°	94°	94°	93°
Acute,	86°–86° 30′			86°	

On examination by polarized light, the crystals were found to refract doubly.

The isolated plates or crystals appear transparent, and nearly colorless, but when the mineral is seen in mass it has a beautiful pink or rose color, and is not unlike that of peach blossoms.

The hardness is about 2 (Mohs's scale), or nearly that of gypsum.

I obtained for the specific gravity at 60° F. 2·666, which is the result of one determination only, and needs repeating, as minute parts of the light scales floated upon the water.

The reactions of the mineral before the blowpipe are as follows.

BB. In forceps—contracts greatly, whitens, becomes opaque, and when cold is brown and has a silvery lustre. Infusible.

BB. In tube, gives off water abundantly. With borax in *oxydating* flame dissolves, giving a slightly blue glass which becomes reddish on cooling, and when cold has a purple or amethystine tinge. In *reducing* flame nearly the same.

With microcosmic salt; a blue glass, while hot amethystine, and red when cold; the bead becomes opaque when but slightly heated, and retains a pink color. With carbonate of soda, a green reaction similar to that given by manganese.

The crystals dissolve rapidly in dilute chlorohydric acid, with brisk effervescence; ammonia precipitates from this solution a bulky precipitate of a delicate pink color which is insoluble in an excess of the precipitant; the filtrate leaves no residue on being evaporated to dryness.

The following are the chemical characters of the mineral as given by Prof. J. Lawrence Smith, who has kindly examined it for me.

"The mineral gives all the reactions for lanthanum and didymium, water and carbonic acid. A gentle heat expels its water. It is readily dissolved in the stronger acids with violent effervescence, and if sulphate of potash be added to the solution, a granular precipitate takes place (characters belonging to cerium lanthanum and didymium). A concentrated cold solution of the sulphate deposits on boiling small prismatic crystals, which, redissolved on the cooling of the solution, afford unmistakable evidence of the presence of sulphate of lanthanum or its like. The mineral when heated to redness loses all its water, and a large portion of carbonic acid, but it requires a long continued heat to expel the last traces; the residue is of a light brown color; if this be treated with nitric acid re-ignited and then thrown into water containing

one-hundredth part of nitric acid, it will be slowly but completely dissolved, an evidence of the absence of cerium. As to the presence of didymium, it was only indicated by the color of the oxyd; the quantity of the mineral was too small to enable me to decide in any way as to the amount of that substance mixed with the lanthanum.

A quantitative examination, in which every thing was estimated directly, gave,

Water, - - - - -	24·09
Carbonic acid, - - -	22·58
Oxyd of lanthanum and didymium,	54·90
	101·57

The excess in the analysis is due to the peroxydation of a portion of the oxyds; but as we are not yet possessed of any accurate method of reducing them, the analysis must stand as it is. Other analyses were made of the separate constituents, the results of which accord with the above, and give the formula, $\dot{La}\dot{C}+3\dot{H}$, the per-centage of which is water 25·95, carbonic acid 21·11, oxyd lanthanum 52·94 = 100·00.

This carbonate is the artificial carbonate commonly obtained by adding the alkaline carbonates to a soluble salt of lanthanum."

I have obtained the following per-centage weights, for the separate constituents.

	$\dot{La}$	$\dot{C}$	$\dot{C}+\dot{H}$ (by ign.)
I.	54·27	19·13	——
II.	54·93	——	45·07
III.	54·64	——	45·36

Another determination of carbonic acid gave 19·936 p. c. Subtracting the mean of the two determinations of carbonic acid from the loss by ignition gives, 25·68 per cent. as the amount of water.

These results are sufficient to show that the mineral is a simple carbonate of lanthanum with three atoms of water, and I prefer to describe it as *Lanthanite*, although its composition is very different from that given by Mosander to the mineral found at Bastnäs in Sweden, which has been examined in small quantities only, and possibly in a state of admixture, so that considerable doubt as to its constitution seems to exist; it is now important that it should receive a reëxamination as it very probably has a composition corresponding with the mineral just described.

The occurrence of carbonate of lanthanum almost chemically pure with zinc ores in limestones of silurian age, is a fact of no small interest. It should be remarked, however, that the limestones have decomposed to a considerable depth, and left the fine ore, together with peroxyd of iron and manganese, in the soil; the Lanthanite was only six feet below the surface.

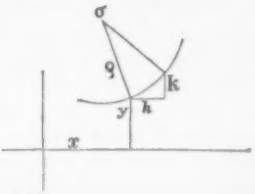
New York, March 1853.

ART. XXV.—*The Normal of Curvature;* by GEORGE CLINTON WHITLOCK, Prof. of Chem. and Nat. Hist. in Genesee College.

THE complicated method of the osculatory circle and its metaphysical difficulties, has conducted me to the following solution of the problem of curvature, founded on the natural and simple relations of intersecting normals to the arc embraced by them.

The equation of the normal to a curve at the point (y, x), is

$$y_1 - y = -\frac{1}{y'}(x_1 - x), \quad \left[y' = \frac{dy}{dx}\right]$$



or $y'(y - y_1) = x_1 - x$,

y_1, x_1 being the co-ordinates of any point in the normal; so

$$(y+k)'(y+k-y_2) = x_2 - (x+h),$$

is the equation of the normal intersecting the curve in the point $(y+k, x+h)$. Or, for σ, the point in which the normals intersect, distinguishing the coördinates of this point by y_σ, x_σ, the equations of the normals become

$$y'(y - y_\sigma) - x_\sigma - x,$$

$$(y+k)'(y - y_\sigma) + (y+k)'k = x_\sigma - x - h;$$

$$\therefore [(y+k)' - y'](y - y_\sigma) + (y+k)'k = -h,$$

$$\text{and } \frac{(y+k)' - y'}{h} \cdot (y - y_\sigma) + (y+k)' \cdot \frac{k}{h} = -1;$$

from which, reducing h to zero and observing that $\left[\frac{k}{h}\right] = y'$ and

$$\left[\frac{(y+k)' - y'}{h}\right] = \left[\frac{\varphi'(x+h) - \varphi' x}{h}\right] = (\varphi' x)' = \varphi'' x, \ [y = \varphi x],$$

we have $$y''(y - y_\sigma) + y'^2 + 1 = 0,$$

or $$y_\sigma - y = \frac{y'^2 + 1}{y''}, \quad \text{and by substitution,}$$

$$x - x_\sigma = \frac{(y'^2 + 1)y'}{y''}.$$

Therefore, putting ϱ, which we denominate the "*Normal of Curvature*," for the length of the normal embraced between the point σ and the curve when $h = 0$, there results,

$$S = \sqrt{(y_\sigma - y)^2 + (x - x_\sigma)^2} = \frac{(y'^2 + 1)^{\frac{3}{2}}}{y''}.$$

It is evident that the Normal of Curvature applies much more directly and simply to the problem of central forces than does the Radius of Curvature.

Genesee College, May 7th, 1853.

ART. XXVI.—*Proposed Modification of the construction of the Ericsson Engine, with a view to increase its available power;* by FREDERICK A. P. BARNARD, Professor of Chemistry and Natural History in the University of Alabama.

The deep interest with which the public have regarded the recent attempt of Capt. Ericsson to employ the elastic force of air expanded by heat, for the propulsion of vessels at sea, appears to have given place to a feeling almost of disappointment. Whatever hopes might still have been entertained by observers whose opinions are governed by visible results only, and not by theoretic deductions, of the practicability of attaining a materially higher degree of power with greater experience, such anticipations can hardly be indulged with any confidence by those who have read with attention the searching examination of the performance of the experimental engines of the "Ericsson" ship, made by Prof. Norton, in the last number of this Journal.

If, in connection with the article of Prof. Norton, we refer to the theoretic investigation of the general question by Major Barnard, of the U. S. Engineers, in the April number of Appleton's Mechanics' Magazine, we shall be satisfied that there are difficulties in the way of increasing the efficiency of the engine in its present form, too serious to be easily surmounted. As to the fact that it has not yet been brought up nor nearly up, to the original estimate of the inventor, no doubt can possibly be entertained in any quarter.

Taking the engine in its present form, there appear to be three modes, and only three, by which its power may be increased; and all these are attended by practical disadvantages of such a nature as greatly to limit their availability. The first is, obviously, to increase its size; but, in so doing, we increase the weight proportionally, and thus unfit the engine for the uses of locomotion. The second, is to enlarge the supply cylinder only, increasing the quantity of air employed at each stroke; but this, besides requiring a similarly increased amount of fuel, necessarily increases rapidly the irregularity, or rather, inequality of action of the driving power, at different periods of the stroke. The third mode, is to diminish the fractional part of the stroke during which the air is admitted to the working cylinder, or to place the cut-off earlier in the stroke. But here a practical limit very shortly presents itself, in the occurrence of a resistance towards the close of the stroke, superior to the pressure on the working piston. With double engines connected as are those of the "Ericsson," such a resistance is not inadmissible within certain limits; because the negative pressure in either engine may be overcome by the positive power of the other; but even with such

it may easily be shown, that when the cut-off is at a little short of $\frac{2}{3}$, the driving power will be reduced nearly or quite to zero, at the points where the component of negative pressure directed against the power of the companion engine is near its maximum; and, with a two-thirds cut-off, which has been recommended by Prof. Norton, and which is larger than that sometimes or usually employed in fact on the "Ericsson," the balance of positive power at these points will become but little more than one pound to the square inch. This indeed, is true only when there is no leakage:—which, however, is simply saying that the disadvantage fails to become serious only in proportion as the advantage sought is unattained.

In speaking of the possible modes of improving the performance of the engine, it is taken for granted that the safe limits of heat have already been experimentally found; and that consequently there is no room to look for improvement in this direction. And it is also admitted that the performance of the engines of the Ericsson will very possibly and even probably, be improved, if it shall be found practicable to save the large amount of power, now evidently lost by leakage. But it seems not at all difficult to show that these engines, with their present dimensions and form, can never develop the amount of power which has been estimated for them by their ingenious inventor, even if all leakage should be stopped; unless the heat imparted to the air should be made greater than we are told it has yet been.

Whether any modification of the form of the engine can be effectual to remove the difficulties in the way of its improvement, or even partially to remove them, is a question which deserves examination. Apparently the hope of a favorable solution is not desperate; and the object of the present paper is to offer a single suggestion looking in that direction. In order that it may be intelligibly presented, it will be necessary to throw the conditions of the problem into mathematical form. The symbols employed by Maj. Barnard, in the article above alluded to, will be adopted so far as they serve.

Put a = cross section of working cylinder.

ma = the same of supply cylinder.

t = the tension of the air in reservoir, when working with any adjustment of the cut-off.

t' = the same, when working without cut-off.

1 = length of stroke; l = fractional part of stroke up to cut-off.

n = ratio of expansion by heat referred to a unit-volume at the density of the air in reservoir.

15 lbs. = pressure of the atmosphere to the square inch.

1 = density of the external air, relatively to that in reservoir.

The consumption of air at each stroke, evidently equals al in bulk, it having been expanded n times by heat,

Same, reduced to density of reservoir, $=\frac{al}{n}$.

Which would fill the supply cylinder to the height, $=\frac{l}{mn}$.

Having a density $=\frac{mn}{l}$; and a tension $=\frac{15mn}{l}$.

Now, if $l=1$, or there be no cut-off, this expansion becomes $15mn$;—hence, $t'=15mn$.

But, if there is a cut-off, $t=\frac{15mn}{l}=\frac{t'}{l}$, and $t'=lt$.

If there is a cut-off, the air works by the expansion due to its natural elasticity during the remainder of the stroke, and its ultimate tension $=lt$, which, as above, $=t'$. Hence, the final tension of the air in the working-cylinder is constant, wherever the cut-off be placed, and is the same as if no cut-off were used.

From these data it is easy to find an expression for the mean effective pressure during a single stroke; this being equal to the whole upward pressure on the working piston, minus the resistances divided by the length, which is unity. This expression, reduced to its simplest form is as follows, putting P to represent the mean effective pressure during the stroke:—

$$P=15a(mn-1)+15am\,((1-n)\,\mathrm{hl}\,l-\mathrm{hl}\,mn).$$

As n is necessarily greater and l less than 1, it is evident that, m and n remaining unchanged, the power will increase while l diminishes, and this without limit. A different conclusion drawn by Prof. Norton, seems to have resulted from leaving out of view a portion of the resistance.

But, while this is the mean pressure, it will be seen that the actual pressure exerted at different periods of the stroke is very variable. The maximum will occur in the beginning when the positive pressure is $=at$, and the resistance simply that of the atmosphere $=15a$. The minimum occurs at the close, when the pressure is $=at'$, and the resistances $=amt+15a\,(1-m)$. We have seen t' to be constant, m and n remaining the same, whatever may be the value of l. But t increases inversely as l, and without limit; so that $amt+15a(1-m)$ may soon be equal to, or exceed at'.

This circumstance practically restricts the power of a single pair of cylinders within a moderate limit. But when two pairs are connected as in the "Ericsson" ship, so that one may be at mid-stroke when the other is encountering the greatest resistance. each may help the other out. And this it may do, even when the resistance exceeds its own positive power at the moment;

since a large component of the resisting pressure will be thrown upon the crank and shaft. Nor is the power thus expanded by one engine to relieve the other to be regarded as a loss, since in the theoretical estimate of the power of either, the whole resistance is counted as negative.

Still the reduction of the joint power of both engines to zero, or nearly to zero, at any point, is undeniable, especially when it is considered that this is a state of things resulting from an actual increase of the mean pressure. The great evil resulting from the use of a short cut-off, is inequality of action, and the advantage of resorting to this expedient must be practically limited, unless a remedy can be found for this difficulty.

To illustrate this fact, let us take an example. Putting $m=\frac{2}{3}$, $n=2$, and $l=\frac{3}{4}$, we shall have $at'=20a$, and $amt+15a\ (1-m)$ $=22\frac{1}{2}a$; an excess of resistance nearly equal to three pounds on the square inch of the entire surface of the working cylinder. But n cannot equal 2. In practice, it will, probably, rarely exceed 1·8; and will more probably (a point to be considered further on) fall below 1·6. Put $n=1{\cdot}8$, and $l=\frac{3}{4}$. Then, $at'=18a$; and $amt+15a\ (1-m)=23a$; the resistance exceeding the power of the engine by $5a$, which, putting $a=22100$ sq. inches, as in Ericsson's engines, $=110500$ pounds.

The power of the companion engine, at this time, (taking it at mid-stroke) will be $=at=27a$; and the resistance the same as in the former case, viz. $=23a$; giving an effective pressure of only $4a$, and leaving a balance of resistance against both engines $=$ 22100 pounds.

If we would ascertain at what point of the stroke, in either engine, working as above, equilibrium will occur between pressure and resistance, we have only to make the resistance $23a$ which is constant for more than half the stroke, equal to $\frac{t'}{x}a$; or $t'=23x$, or $23x=18$; and $x=\frac{18}{23}=\cdot78$.

Now, if the connecting rod be not more than four times the length of the crank, we may easily show that the power of a single engine, worked as here supposed, will entirely fail, while the angle between the crank and the line of the centre, or line of neutral effect, is still more than 70°, in the pushing stroke, and not much less in the pulling. At this distance, should the companion engine be called into help, it expends a power greater than the resistance it overcomes. But as this is only the initial point of the resistance, no serious task is imposed on the companion, until the stroke is considerably farther advanced.

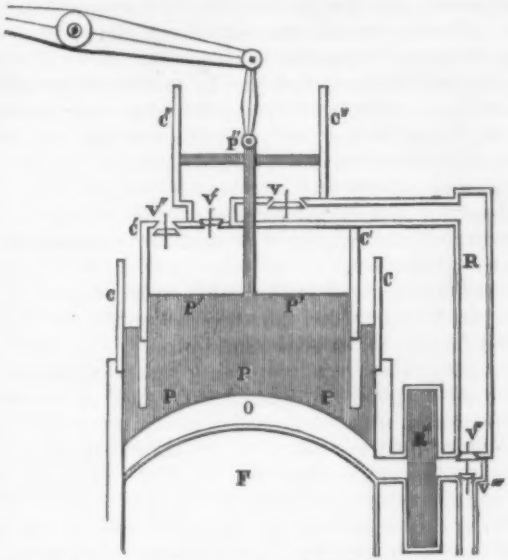
The point at which the tax upon the companion will become a maximum, will vary with the position of the cut-off, and with the proportions of the parts of the engine. In the case supposed,

it occurs between 40 and 45 degrees from the neutral line, and varies very slowly, through a considerable arc: the mechanical advantage of the driving engine increasing nearly as the resistance of the opposing. During this time, the effective pressure is reduced below $1\frac{1}{2}$ pounds to the square inch. The action, therefore, of the double engine, though not entirely neutralized by this cause, is rendered very undesirably unequal.

Without going into a more minute exposition of this branch of the subject, it is the design of the present article to suggest a modification of the form of the engine, by which it is believed that the unequal action resulting from the use of high tension may be in a measure removed, so that single engines may work with larger supply cylinders, without intervals in which the power will be zero; and double engines may carry the tension of the air in the reservoir to a much higher degree than is practicable at present, without encountering the difficulties which have been mentioned.

The proposed remedy is not entirely unobjectionable itself; but it is apparently recommended by advantages more important than any objections which have yet presented themselves. And if its adoption shall render it possible to obtain as high power as has yet been reached in practice, from materially less piston surface, the most serious of these objections, which arises from an increase of the number of parts, and therefore of weight, will disappear. Possibly the modification may ultimately lead to a reduction of weight.

That the proposition may be understood, it is proper here to observe, that, at the commencement of the stroke, there is an amount of pressure which, at a high tension of the air upon these huge pistons, becomes absolutely enormous. With the tension aimed at by Ericsson, viz. 12 lbs. above the atmosphere, it becomes no less than 265000 pounds. Before the completion of the half-stroke, this is reduced to one-third of its value, when it remains constant up to the cut-off, at the two-thirds' stroke, after which it rapidly diminishes, becomes zero at eighteen twenty-thirds of the stroke, and thence finally negative to the end. The object of the modification about to be suggested, is to provide a relief for the mid stroke, and to protract, to some extent, the period of positive action, by imposing a part of the burthen of overcoming the resistance upon the earlier part of the stroke, at present comparatively free. In order to effect this object, it is proposed to employ three cylinders and three pistons where Ericsson employs only two; and to extend over a complete double stroke the labor of driving each fresh charge of air from the atmosphere into the reservoir.



CC, Working Cylinder.
C′C′, Condensing "
C″C″, Supply "
V, V′, V″, &c., Valves.
R′, Regenerator,
PPP, Working Piston Surface.
P′P′, Condensing Piston Surface.
P″, Supply Piston.
R, Reservoir,
F, Furnace.
O, Hot Air Chamber.

A reference to the accompanying diagram will explain what is meant. Let CC be the working cylinder, C′C′ a second cylinder, corresponding to Ericsson's supply cylinder, but which will here be called the condensing cylinder, and C″C″ a third, which may be called the proper supply cylinder of this proposed engine. Let P be the working surface of the large piston, P′ the condensing surface of the same piston, and P″ the supply piston.*

The air is proposed to be admitted through valves on the top of C′C′ into that cylinder, it is to be driven from that cylinder into C″C″, through valves in the bottom of it, this cylinder hav-

* To avoid giving the pile of cylinders too great altitude, it is proposed to sink the condensing cylinder considerably within the working cylinder. For this purpose a portion of the interior of Ericsson's solid pistons must be removed, and the central part made thicker, as represented. The working-beam is to be above the whole, as in Ericsson's stationary single engines, instead of being placed between the supply and working cylinder, as in the ship.

It will be observed, that by closing the top of the cylinder C″C″, and placing valves in P″, we may, if we please, cause the communication with the reservoir to be made at the top of the pile, as in the Ericsson engines. This would have the advantage of allowing larger valve space between C′C′ and C″C″; but it would require the working beam to be placed somewhat higher, which, in a ship, may be a consideration worth attending to.

ing the capacity, predetermined, to bring it to the density of the reservoir. Finally, by the descent of the piston P″, it is to be discharged through V into the reservoir, R.

No attempt will be made here to discuss difficulties of a merely mechanical nature. Some such are foreseen, and also the means of obviating them; but if the proposed modification offers a real improvement, it will be time to consider them seriously when the subject acquires a practical importance.

The disadvantages of the suggested plan are obvious at first sight; and therefore they may as well be enumerated at once, in advance. They are,

1st. A multiplication of parts, always to be avoided, if possible.

2d. An increase, to some extent, of weight.

3d. The friction of an additional piston.

The advantages are recognized only upon a more careful consideration. It will be seen, first, that the task of driving the air, after condensation, into the reservoir, is, by this arrangement, distributed equally over the entire stroke, instead of being confined, as before, to a little more than one-half of it. The total expenditure of force necessary in effecting this object, is, of course, neither increased nor diminished by the change. In the second place, the air of the condensing cylinder acquires its maximum of density only at the very termination of the stroke; and hence the maximum opposition which it offers to the motion of the piston is deferred to the latest possible moment, instead of growing up rapidly before the completion of the half stroke, as in the present engines. In all this, there is no gain of power, certainly, but there is a great gain in equality of action. It might seem, indeed, at first thought, that there is a loss of power, since the elastic force of the air undergoing condensation constitutes a resistance, according to this arrangement, throughout the entire stroke: but it will presently appear that there is a compensation for this, in the fact that this resistance is virtually exerted on only a portion of the piston P′, equal to $P' - P''$. There is, in fact, no power at all absolutely gained or lost; but a great deal of power is believed to be made *available* by this construction, which could not otherwise be employed. The effective pressure will be materially reduced at the commencement of the stroke, but will be greatly increased at mid-stroke, and will be more uniformly diffused over the entire stroke, not, indeed, doing away with, but deferring, the great resistance at the close.

All this can be made to appear only by the aid of mathematical formulæ. The expression for mean pressure, though constructed upon somewhat different data from the former, assumes identically the same shape in the end, and is,

$$P = 15a\,(mn-1) + 15am\,(\,(1-n)\,\mathrm{hl}\,l - \mathrm{hl}\,mn)$$

If we would more particularly compare the proposed engine with that of Captain Ericsson in its present form, in regard to uniformity of action, we cannot do better than to select the points of maximum and minimum pressure in each. If the engines are double, then, when one is in the position of maximum power, the other will be at a mean, or at as near an approach to a mean, as the case admits of. We shall find that, while the plan now proposed will materially reduce the pressure at the maximum point below that of the Ericsson engines at the same point, it in so doing only reserves a large amount of force, to be subsequently expended upon a part of the stroke where the mechanical advantage attending its application is much greater. The minimum pressure in single engines, must, in the nature of things, be the same in both forms of construction; but in double engines, *the joint force of the pair* at minimum will be much superior in the form now proposed, to what it can be in the present. In comparing these joint forces, in the expressions below, they have been treated as if they were exerted in the same straight line, instead of being perpendicular to each other in mean direction. But this will not interfere with the object in view, which is merely to illustrate the difference between the two constructions, in regard to uniformity of action. The maximum pressure, in a double engine, will obviously occur when one of the pistons is commencing its stroke, the other one then in action being about at mid-stroke. In Ericsson's engines, we have seen that the effective pressure on the first may be expressed by the form,

$$P = at - 15a \qquad \text{(i)}$$

while that on the second will be,

$$P = at - amt - 15\,(1-m)\,a \qquad \text{(ii)}$$

and that on both together is,

$$P = (2-m)\,(t-15)\,a \qquad [I]$$

In order to reduce to a corresponding expression the condition of one of our proposed engines at the same moment, we must first determine the cross-section to be given to the cylinder C″C″, in order that its capacity may be just equal to the bulk of the air in C′C′, reduced to the required density. Now this bulk, being that of the constant supply, must be also equal to the constant consumption, which we have seen to be $= \frac{al}{n}$. Of two equal but dissimilar cylinders, the bases must be inversely as the altitudes. Hence,

$$1 : \frac{l}{n} :: a : m'a$$

in which m' represents the ratio of the cross-section of C″C″ to that of CC, and is obviously equal to $\frac{l}{n}$.

At the commencement of the stroke of one of the pistons, the pressure on its surface will be at, as before. But this will be opposed not only by $15a$, (the pressure on its upper surface) as in the former case, but also by that of the air in cylinder C″C″ at the other end of the working beam, whose cross-section is $\frac{l}{n}a$ and tension t. The atmospheric pressure on the upper surface of the smaller piston favors the power, so that the expression for total effect contains these four terms,

$$P = at - 15a + 15a\frac{l}{n} - at\frac{l}{n}$$

$$= 15a\left(\frac{mn-l}{l} - \frac{mn-l}{n}\right) \quad (1)$$

For the simultaneous effective pressure upon the piston, in action in the companion engine, at mid-stroke, we have,

Pressure on under surface of working piston $= +at$

Atmospheric resistance, upper surface $= -15(1-m)a$

Resistance, partially condensed air, on P′ $= -\frac{30m^2n}{mn+l}a.$

Favoring pressure of same, on P″ $= +\frac{30lm}{mn+l}a.$

Resistance, condensed air, passing into reservoir $= -at\frac{l}{n}.$

The atmospheric pressures on the two pistons, P″, at opposite ends of the beam, balance each other.

The co-efficient of a, in the third term, $\frac{30m^2n}{mn+l}$, is obtained as follows. At mid-stroke, the undergoing condensation half fills cylinders C′C′ and C″C″. Its bulk is therefore equal to $\frac{1}{2}\left(m+\frac{l}{n}\right)a$. Let t'' = the corresponding tension, and we have

$$\frac{1}{2}\left(m+\frac{l}{n}\right)a : ma :: 15 : t'' = \frac{30mn}{mn+l}$$

which tension, acting on the surface of $P' = ma$, gives the term as above. In like manner, t'' acting on the surface, $\frac{l}{n}a$, of P″, gives the next following term.

All the expressions above, united and reduced, give

$$P = 15a\left(\frac{mn-l}{l} - 2\frac{m(mn-l)}{mn+l}\right) \quad (2)$$

This, added to the last, gives, for the effective power of both engines,

$$P = 15a\left(2\frac{mn-l}{l} - \frac{mn-l}{n} - 2\frac{m(mn-l)}{mn+l}\right) \quad (II)$$

Assigning now to l, m, and n, the values heretofore employed respectively, we shall find, by comparing (i) and (ii) with (1) and (2), and by comparing (I) with (II), that while the total effective pressures of both the mutually auxiliary engines, taken together, are not widely different, yet the parts which make up this total are remarkably unequal in the two cases. The substitutions of the numerical values of the letters, give the following results; a, as before, being taken at 22100 sq. in.

(i) $= 12a = 265200$ lbs.
(1) $= 7{\cdot}555a = 166977$ "
(ii) $= 4a = 88400$ "
(2) $= 6{\cdot}286a = 138920$ "
(I) $= 16a = 353600$ "
(II) $= 13{\cdot}841a = 305897$ "

It appears from these comparisons, that, at the moment of maximum joint effective action, one of the laboring pistons of Ericsson's engines is sustaining three times as great a pressure as the other; and that this is precisely the piston of which the power is applied at the greatest mechanical disadvantage. By the other construction, this inequality is much reduced. The *total* of effective action is also diminished at this point by the proposed plan; as it was designed to be, for the benefit of a later period of the stroke.

The point of maximum resistance is likewise, when a cut-off is employed, the point of minimum elasticity of the air in the working cylinder—that is to say, the end of the stroke; and this will therefore be the point of minimum joint effective pressure in the pair of engines. In Ericsson's engines, we have, for the piston finishing its stroke,

$$P = at' - mat - 15(1-m)a \qquad (i')$$

and for that at mid-stroke, as before,

$$P = at - amt - 15(1-m)a. \qquad (ii')$$

For an engine working without a cut-off, these expressions are obviously equal; but it is otherwise for one which works expansively.

In the newly proposed form, the expression for the first piston is exactly the same as (i'). There is no escape from the necessity of encountering somewhere a resistance equal to the full tension, t, exerted against the entire surface of the condensing piston. This, moreover, happens, when t has run down to t' in the working cylinder; that is, when the positive pressure is least. We have, therefore, for piston finishing its stroke,

$$P = at' - amt - 15(1-m)a \qquad (1')$$

And, for the piston, at mid-stroke, as before, (2)

$$P = 15a\left(\frac{mn-l}{l} - 2\frac{m(mn-l)}{mn+l}\right) \qquad (2')$$

The total of i′ and ii′, for the Ericsson engine, is, (t and t' being eliminated,)

$$P=15a\left[\frac{mn}{l}(1+l-2m)-2(1-m)\right] \qquad (I')$$

The similar total for the other is,

$$P=15a\left[m(n\frac{1-m}{l}-2\frac{mn-l}{mn+l}+n+1)-2\right] \qquad (II')$$

Comparing these, as before, we have,

(i′)	$=-5a=-110500$	lbs.
(1′)	$=-5a=-110500$	"
(ii′)	$=+4a=+88400$	"
(2′)	$=+6{\cdot}286a=138920$	"
[I′]	$=-a=-22100$	"
[II′]	$=+1{\cdot}286a=+28420$	"

It thus appears, that, at the point of minimum pressure, engines constructed in the proposed form would have a considerable balance of positive power, even were their action directed in the same straight line, which it is not. In point of fact, arranged as they are, Ericsson's engines, with a cut-off at two-thirds' stroke, always preserve a balance of positive power at the point of greatest exigency; but for the same reason, the balance is much more in favor of the form now proposed, hardly descending at any time below $4a$. This estimate is founded on the supposition that the connecting rods are at least four times as long as the crank.

Since hot-air engines, not working in pairs, infallibly encounter a resistance greater than their direct positive power at the moment, whenever, working with a short cut-off, they approach the close of the stroke, the power of such engines is seriously limited. It appears that by adopting the construction here suggested, the zero point of pressure will be thrown materially later, and the limit within which the engine can be worked without encountering predominant negative pressure, will be enlarged. These are points upon which, with others, it is proposed to enter more fully hereafter, should the importance of the subject appear to justify it.

In what has been said in the present paper, no notice has been taken of the effects of leakage, of friction, or of the clearance of the cylinders. Those are matters of practical importance, but of no immediate interest in a discussion like that just now in hand.

Thus far, moreover, the proportions and dimensions of the Ericsson engines have been adopted, and a cut-off has been supposed to be placed at two-thirds of the length of the stroke. By an application of the formulæ however, it will be seen that single engines of the proposed form may be worked with much larger supply cylinders than have yet been used, with corresponding increase of power, and without negative pressure; and that double engines, by the use of a cut-off, and by working

against some negative pressure, may, with similarly enlarged supply cylinders, acquire much greater efficiency.

Without enlarging upon this point, it will be sufficient to take the expression for mean pressure already given, and substitute in it larger values for m. If $m=1$, and $l=1$, n being 1·8, as before, we shall obtain a mean pressure of 70200 lbs. and, with nine revolutions, and a 6 foot stroke, a horse-power of 230.

If l be put $=\frac{2}{3}$, m and n remaining the same, the horse-power rises to 1340. But with this adjustment, the periodical resistance becomes intolerable. Indeed, it is obvious that when m is equal to 1, no single engine can work with a cut-off at all, without a heavy fly; nor with a short cut-off, even with the aid of such a regulator. For when $m=1$ and l also $=1$, the power and resistance are exactly balanced at the end of the stroke.* But double engines may have great power, with a condensing as large as the working cylinder, and without objectionable negative pressure. Thus, put $m=1$ and $l=\frac{2}{3}$, and the horse-power of a single engine rises to 390.

The maximum effect is not attained, however, with $m=1$. The expression for mean pressure, viz.,

$$P=15a\,(mn-1)+15am\,(\,(1-n)\,\mathrm{hl}\,l-\mathrm{hl}\,mn)$$

becomes a maximum (n and l being constant) when

$$\mathrm{hl}\,m=(n-1)-\mathrm{hl}\,n+(1-n)\,\mathrm{hl}\,l.$$

Which with $n=1{\cdot}8$, and $l=1$, gives $\mathrm{hl}\,m=\cdot212214$, and $m=1{\cdot}2365$. The power increases very slowly however, with the approach to the maximum, rising (with $l=1$) only from 230 to to 254 horse-power, with an increase of the supply of air amounting to nearly 25 per cent. The question of the power of the furnace to heat this great amount of gas becomes now serious; but the more important question is the economical one; it being self-evident that the gain in power from this source, is not, beyond certain limits, a compensation for the increased amount of fuel consumed.

If, nevertheless, the form, which it has been proposed in this paper to give to the engine, be adopted, it may easily be made to appear that true economy will be consulted by enlarging the supply cylinders beyond the dimensions adopted by Ericsson. It was a part of the plan of this paper to present certain calculations upon the question of the most economical proportions. But when these are settled, (if they can be so theoretically) the important practical question remains for experimental determination, whether or not the furnaces can be made competent to supply the increased

* In Ericsson's engines, if $m=1$, the power is *zero* throughout *half the stroke*, even when working without a cut-off. In fact, this paralysis of the power exists throughout much more than half the stroke, in consequence of the heat developed by compression, as is shown further on.

demand for heat. To avoid protracting this discussion, this whole subject is reserved for future consideration.

In regard to the power actually developed by the engines of the "Ericsson" ship, it is much below what, from the data, might have been expected. The inventor was justified in believing that, with the proportions and dimensions adopted, with a heat of 480° F. or upward, and with a two-thirds' cut-off, each engine of the pair would exert a power equal to that of 300 horses. To what cause their inferior performance, is to be attributed, is not perfectly clear. It may be owing, in a measure, to a deficient heating power. It seems impossible to ascribe it wholly to leakage. It is worth consideration, whether, after all, it is not in a great degree a consequence of the expenditure of much of the force developed, upon a portion of the stroke where it acts at the highest mechanical disadvantage; and of another portion, in the mutual aid which these engines are required to furnish each other, after their power has become very much reduced, and when they are precisely in the position in which they ought to act most efficiently.

One advantage which must result from the adoption of the improvement which it is the object of this paper to propose, has not thus far been alluded to. It consists in the unintermitting and uniform flow of the supply of condensed air into the reservoir.*

As a consequence of this fact, indeed, we may be enabled to dispense with a reservoir almost entirely, without increasing the disadvantge of a perceptible fluctuation in the pressure on the working pistons.

Thus far no notice has been taken of the important fact, that the temperature of the air which is driven into the reservoir by the supply cylinder, is very materially changed by the compression to which it is subjected. This circumstance cannot but exert an important influence on the working of the engine. But as yet nothing which has been written on this subject, and which has fallen under the notice of the present writer, has touched this material point.

It is proposed, therefore, in brief, to examine the question, what should be the legitimate influence of heat developed by compression, and to modify the formulæ used in completing power, so as to allow for that influenee. Hitherto the tension of the com-

* In the reservoir of a single engine, working with a cut-off, there would still be a slight fluctuation of pressure, because the draught is intermitted, while the supply is constant. But, in double engines, employing but a single reservoir, this fluctuation will nearly disappear. It is evident that the pressure might be rendered absolutely constant, if the case required it, by means of a large piston working in a cylinder attached to the reservoir, and weighted to the exacted pressure required. A contrivance similar to this is employed to equalize the blast of tub-bellows in furnaces. For a locomotive engine, however, it would be a cumbrous and undesirable attachment.

pressed air has been inferred as if it depended upon nothing but altered density, according to the law of Mariotte. But this is to compute the power of a caloric engine, by disregarding a material part of the caloric in the case.

It is evident that, if t is the tension of the air in the reservoir, then the air in the supply cylinder will open the valves and begin to enter the reservoir (in consequence of the elasticity due to heat of compression), before the density reaches $\frac{t}{15}$. In Poisson's *Traité de Mecanique*, we find the following formula adapted to this case.

$$p' = p\left(\frac{\varrho'}{\varrho}\right)^{\gamma}, \qquad (I)$$

In which p and p', ϱ and ϱ', denote the pressures and densities of the same air before and after compression, respectively, and γ expresses the ratio between the specific heats of air at constant pressure and at constant volume. The mean of the valves given for γ by Poisson, is 1·36.*

The first consideration which presents itself, is that the elevation of temperature in the supply cylinder, (which will shortly be imparted to the reservoir,) will reduce the value of n: for n has been referred to a unit of bulk having the temperature and density of the air of the reservoir. It is evident therefore, that taking l, m and the temperature of the working cylinder as constant, the value of n will be constant also, and may be determined by the aid of the foregoing formula, suitably combined with the following, which denotes the sensible temperature of the air after the change;

$$\theta' = (\Theta + \theta)\left(\frac{\varrho'}{\varrho}\right)^{\gamma - 1} - \Theta, \qquad (II)$$

In which θ and θ' express the temperatures before and after the change of density, Θ represents the number of degrees of increase of temperarature required to double the bulk of air taken originally at the temperature of 32° Fah., (=491° F., according to Regnault,) and ϱ and ϱ' are used as before.

But, assuming these several elements to be variable, n becomes a fraction of all of them. We may find a general expression for its value, and thus, if we please, eliminate it, as follows.

* In the London and Edinburgh Phil. Mag., for June, Mr. Rankine employs 1·41 (the value of this ratio as determined from the velocity of sound,) in comparing the theoretic results of his inquiries upon the specific heat of air, with the recently published experimental determinations of Regnault. The values so closely accord, as to make it evident that this number is much nearer the truth than that employed in the text. As the present article was written, however with a view to publication in the July number of the Am. Journal of Science, the article, above alluded to had not fallen under the notice of the writer, at the time of its preparation. The computations which follow, stand as originally made, with the value of $\gamma = 1{\cdot}36$.

Put T = temperature of air in working cylinder.
θ = temperature of the weather.
θ' = temperature of air after compression by the condensing cylinder.*
Θ = number of degrees of heat required to double vol. of air, at original temperature of 32° F.
ϱ = density of the atmospheric air at the time, which may always be assumed = 1.
ϱ' = density of air in reservoir, which (ϱ being 1) we have already seen must be equal to $\frac{mn}{l}$.

Hence, (II), $\theta' = (\Theta+\theta)\left(\frac{\varrho'}{\varrho}\right)^{\gamma-1} - \Theta = (\Theta+\theta)\left(\frac{mn}{l}\right)^{\gamma-1} - \Theta$.

It is evident that,

$$n-1 = \frac{T-\theta'}{\Theta+\theta'} \text{ or } (\Theta+\theta')n - \Theta = T.$$

And $$n = \frac{T+\Theta}{\Theta+\theta'} = \frac{(T+\Theta)l^{\gamma-1}}{(\Theta+\theta)m^{\gamma-1}n^{\gamma-1}}$$

Or $$n^{\gamma} = \frac{(T+\Theta)l^{\gamma-1}}{(\Theta+\theta)m^{\gamma-1}} \text{ and } n = \left(\frac{T+\Theta}{\Theta+\theta}\right)^{\frac{1}{\gamma}}\left(\frac{l}{m}\right)^{\frac{\gamma-1}{\gamma}}$$

Hence, putting l and m, each $=\frac{2}{3}$, as before, assuming $\theta = 28°$ (weather temp. = 60° F.), and $T = 450°$ (being = 482° F.—as high a heat as is probably safe), we shall have $n = 1{\cdot}55$ very nearly.

Returning to equation (II) with this value of the co-efficient of expansion, we have $\theta' = 116°{\cdot}5$, or $148°{\cdot}5$ above the zero of Fahrenheit.

Equation (I) furnishes also the tension due to this value of n, which is 27·2 lbs. to the square inch.

The formula heretofore given to express the mean pressure will now no longer be applicable; since, in the construction of that formula, density was assumed as a just measure of tension. That is to say, $\frac{t'}{t}$ was put equal to $\frac{\varrho'}{\varrho}$ of Poisson's formula; whereas $\frac{t'}{t} = \left(\frac{\varrho'}{\varrho}\right)^{\gamma}$. Moreover the area of the logarithmic curve will no longer truly express the elastic force exerted by the air during expansion or compression. Instead of this we must substitute that of a different curve, whose abscis, x, is the altitude of the column of air undergoing change of density, and whose ordinate is t'', the tension corresponding to that altitude. For the positive term of variable pressure, we have the maximum tension $= t$, and by (I),

$$t'' = t\left(\frac{l}{x}\right)^{\gamma}.$$

* These temperatures are to be estimated from 32° Fahrenheit, and not from the zero of that scale.

Then, if u represent the area of the curve,

$$du=t''dx=tl^{\gamma}x^{-\gamma}dx$$

$$\int du=\frac{tl^{\gamma}}{1-\gamma}x^{1-\gamma}+C.$$

But, when $x=l$, $u=o$: Hence $C=-\frac{lt}{1-\gamma}$.

At the end of stroke, $x=1$; Hence,

$$u=\frac{l^{\gamma}t}{1-\gamma}-\frac{lt}{1-\gamma}=\frac{lt(l^{\gamma-1}-1)}{1-\gamma},$$

which is to be multiplied into a, the area of the working piston.

For the negative term, or that expressing the resistance of the air undergoing compression, make, x, the abscis, the supplement of the stroke, or the part of the stroke which remains at any time to be performed. Then the bulk of the partially compressed air, at that moment, will be made up of the part amx, in cylinder C′C′, and $a\frac{l}{n}(1-x)$, in cylinder C″C″; or will be a total of $\frac{a}{n}(l+(mn-l)x)$. And the corresponding density will be found from this proposition:

$$\frac{a}{n}(l+(mn-l)x) : am :: 1 : d''=\frac{mn}{l+(mn-l)x}$$

The tension, t'', corresponding to d'', will be (I),

$$t''=15\left(\frac{mn}{l+(mn-l)x}\right)^{\gamma}=15\overline{mn}^{\gamma}(l+(mn-l)x)^{-\gamma}.$$

And, as before, $du=t''dx=15\overline{mn}^{\gamma}(l+(mn-l)x)^{-\gamma}dx$

$$\int t''dx=\frac{15\overline{mn}^{\gamma}}{(1-\gamma)(mn-l)}\Big(l+(mn-l)x\Big)^{1-\gamma}+C.$$

If $x=0$, $u=0$; or $C=-\frac{15\overline{mn}^{\gamma}}{(1-\gamma)(mn-l)}\times l^{1-\gamma}$

If $x=1$, the density is minimum; and then

$$u=P=\frac{15\overline{mn}^{\gamma}}{(1-\gamma)(mn-l)}(mn)^{1-\gamma}-\frac{15\overline{mn}^{\gamma}}{(1-\gamma)(mn-l)}l^{1-\gamma}$$

$$\text{Or}\qquad P=\frac{15mn^{\gamma}}{(1-\gamma)(mn-l)}(\overline{mn}^{1-\gamma}-l^{1-\gamma})$$

which is to be multiplied by the difference of the surfaces P′ and $P''=ma-\frac{l}{n}a=\frac{mn-l}{n}a$, giving, finally, $P=\frac{15m^{\gamma}n^{\gamma-1}}{1-\gamma}(\overline{mn}^{1-\gamma}-l^{1-\gamma})a$.

The several terms, then, which make up the mean pressure, will be as follows:

Positive pressure, before cut off $= +alt$

" " after " " $= +alt\frac{l^{\gamma-1}-1}{1-\gamma}$

Negative pressure, in supply cyl. $= -\frac{alt}{n}$

Balance, neg. pres. in cond. cyl. $= -\frac{15am^{\gamma}n^{\gamma-1}}{1-\gamma}(m^{1-\gamma}n^{1-\gamma}-l^{1-\gamma})$,

Negative atmospheric pressure $= -15a(1-m)$.

Whence,

$$P=alt+alt\frac{l^{\gamma-1}-1}{1-\gamma}-\frac{alt}{n}-\frac{15am^{\gamma}n^{\gamma-1}}{1-\gamma}(m^{1-\gamma}n^{1-\gamma}-l^{1-\gamma})-15a(1-m),$$

which is the mean pressure during the stroke. By eliminating $t\left(=15\left(\frac{mn}{l}\right)^{\gamma}\right)$ and reducing, we shall have,

$$P=15a\,l^{1-\gamma}m^{\gamma}n^{\gamma-1}(n-1)+15al^{1-\gamma}m^{\gamma}n^{\gamma}\frac{l^{\gamma-1}-1}{1-\gamma}-\frac{15am^{\gamma}n^{\gamma-1}}{1-\gamma}$$
$$(m^{1-\gamma}n^{1-\gamma}-l^{1-\gamma})-15a(1-m).$$

But, as we have seen that n is dependent on l and m, this symbol also must be eliminated, in order that the equation may contain only independent variables.

$n=\left(\frac{T+\Theta}{\Theta+\theta}\right)^{\frac{1}{\gamma}}\left(\frac{l}{m}\right)^{\frac{\gamma-1}{\gamma}}$. Put $\mu=\left(\frac{T+\Theta}{\Theta+\theta}\right)^{\frac{1}{\gamma}}$; and $n=\mu\left(\frac{l}{m}\right)^{\frac{\gamma-1}{\gamma}}$.

Substituting this value and reducing, the equation becomes

$$P=15a\Big[l^{\frac{1-\gamma}{\gamma}}m^{\frac{2\gamma-1}{\gamma}}\mu^{\gamma-1}\left(\mu\left(\frac{l}{m}\right)^{\frac{\gamma-1}{\gamma}}-1\right)+\frac{m\mu^{\gamma}}{1-\gamma}(l^{\gamma-1}-1)-\frac{l^{\frac{(\gamma-1)^2}{\gamma}}m^{\frac{2\gamma-1}{\gamma}}\mu^{\gamma-1}}{1-\gamma}\times$$
$$\left(l^{\frac{-(1-\gamma)^2}{\gamma}}m^{\frac{1-\gamma}{\gamma}}\mu^{1-\gamma}-l^{1-\gamma}\right)+m-1\Big]$$
$$=15a\Big[l^{\frac{1-\gamma}{\gamma}}m\mu^{\gamma-1}\left(\mu l^{\frac{\gamma-1}{\gamma}}-m^{\frac{\gamma-1}{\gamma}}\right)+\frac{m\mu^{\gamma}}{1-\gamma}(l^{\gamma-1}-1)-\frac{m}{1-\gamma}\left(1-m^{\frac{\gamma-1}{\gamma}}l^{1-\gamma}\mu^{\gamma-1}\right)$$
$$+m-1\Big]$$

This equation is too complicated to admit of a general discussion. But, by making particular suppositions in regard to m and l, it may be, in some cases, materially simplified. Thus, putting m and l each $=1$, it becomes

$$P=15a\left(\mu^{\gamma-1}(\mu-1)-\frac{1-\mu^{\gamma-1}}{1-\gamma}\right)$$

Which, substituting the numerical values of the symbols, gives $P=2{\cdot}55a=56400$ lbs.; or, with ten revolutions and a six-foot stroke, a horse power of 205.

If we make m and l equal to each other, and put a new symbol, as λ, to stand indifferently for either, the equation becomes,

$$P=15a\left[\lambda\mu^{\gamma-1}(\mu-1)+\frac{\mu\gamma(\lambda\gamma-1)}{1-\gamma}-\frac{\lambda(1-\mu\gamma-1)}{1-\gamma}+\lambda-1\right]$$

If, in this, we put $\lambda=\cdot8$, we shall obtain $P=3\cdot69a=81550$ lbs., or 296 horse power.

With $\lambda=\frac{2}{3}$, we have $P=3\cdot38a=74700$ lbs., or 271 horse power. It thus appears, that, when m and n are equal, the variation is slow below l or $m=\cdot8$. But the uniformity of action is in favor of the higher numbers.

In the expression above, at its maximum value,

$$\lambda=\left(\frac{\mu^{\gamma}-\mu^{\gamma-1}+1}{\mu^{\gamma}}\right)^{\frac{1}{\gamma-1}}=\cdot71226.$$

But the value of P is hardly perceptibly greater at this point, than for some distance on either side of it.

The comparison of these results, however, with those which may be obtained by making m greater than l, will show that it is not true economy to make these two numbers equal. If m be put $=\cdot75$, while l remains $=\frac{2}{3}$, the power will ascend to $4\cdot415a=97570$ lbs., which, supposing two revolutions and six feet stroke as before, gives a horse-power of 354. Putting $m=\cdot85$, and $l=\frac{2}{3}$, the pressure becomes $4\cdot92a=108700$ lbs. $=395$ horse-power.

Values of l and m like these cannot possibly be employed with advantage in an engine constructed on the plan of Ericsson's; since they would render the action almost spasmodic in character. and reduce the minimum power of the pair of connected engines below zero. We have seen that a cut-off was actually used in the ship, which was considerably less than $\frac{2}{3}$; but it is very evident the defects of the machinery prevented the attainment of the tension due to such a cut-off; which, therefore, failing to secure the advantage aimed at, failed also to make the evil very conspicuously manifest. But this evil is sure to occur, and is likely to interfere seriously with, if not completely to counteract, the advantages presented by this means of gaining power, just in proportion as leakage is stopped, or other causes which may keep down the tension are removed.

The construction now proposed will be, in a great manner, free from these disadvantages; and hence the powers last stated, ranging from 350 to 400, are obtainable without difficulty. Such powers are more than sufficient, according to the investigations of Prof. Norton, to make these engines available for purposes of speed in ocean navigation.

Nor are these increments of power accompanying enlargement of supply cylinder, attended with an economical disadvantage. If we compare the powers on the two suppositions, $l=\frac{2}{3}$, $m=\frac{2}{3}$, and $l=\frac{2}{3}$, $m=\frac{3}{4}$, we shall see that, while, in the latter case, the power is increased 30 per cent, the volume of air to be heated is

increased only 12½ per cent. If $m = .85$, the increase of power is 46 per cent., while that of the volume of air is only 28 per cent. It is, nevertheless, still a question to be settled experimentally, to what extent the volume of air can be increased, without exceeding the power of the furnaces. But at any rate we are justified at present in saying, that there is no good reason, as yet, for despairing of the success of this ingenious invention.

Univ. of Alabama, June 1, 1853.

Art. XXVII.—*Note on the Parasitism of Comandra umbellata*, Nutt.; by Asa Gray.

So long ago as the year 1847, Mr. William Mitten, an English botanist, communicated to Hooker's London Journal of Botany, (vol. vi. p. 146, plate 4,) a brief article, on the economy of the roots of *Thesium linophyllum;* in which he shows that the roots of this plant are parasitic; the ramifications of the root forming attachments, by means of suckers, with the roots of adjacent plants of various species. The same parasitism probably occurs in other species of *Thesium*, if not in the genus generally. But I am not aware that the fact has been confirmed on the continental species, which are somewhat numerous, although attention has been called to the subject by the reprint of Mr. Mitten's article in the Annales des Sciences Naturelles (in the volume which bears the nominal date of 1847,) and an interesting extension was at once given to the discovery by M. Decaisne, who detected a similar parasitic attachment of the rootlets of *Melanipyrum pedicularis*, and other rhinanthaceous plants long known to be uncultivable.

In the Botanical Text-Book, I had called attention to the related genus *Comandra*, which replaces *Thesium* in this country, as likely to exhibit the same parasitic economy, but, pressed by other occupations, had neglected to make the examination myself, nor had I any notice of the observation having been made by others, although *Comandra umbellata* is everywhere a common plant in the United States.

The discovery, however, has now been made by my esteemed correspondent, Mr. Jacob Stauffer, of Mount Joy, Lancaster County, Pennsylvania. He has recently sent me fresh specimens of *Comandra umbellata*, with its elongated and woody subterranean stems, giving off numerous roots, the branches of which are often expanded at their tips, into a small tubercle or sucker, which is implanted by its disk-like surface upon the bark of adjacent roots, principally of shrubs. The foster-plants, in the specimens communicated, are Blueberries and Huckleberries,

(*Vaccinium vacillans* and *Gaylussacia resinosa*). Mr. Stauffer's specimens are accompanied by a neat drawing, illustrating the mode of attachment. This I would gladly forward for the engraver: but it will suffice, perhaps, for the present to say, that the attachment is similar to that so clearly exhibited by Mr. Mitten, in the plate which accompanies his article; only that the rootlets in *Comandra* arise from subterannean stems, and the suckers so far as I have examined, do not appear to penetrate the foster root deeper than the surface of its wood.

Since the above was written and in type, I have received from Mr. Stauffer the announcement of his discovery of the parasitism of *Gerardia flava*, accompanied by a drawing which exhibits it, and a specimen which plainly shows the attachment. The numerous branches of the root are not only attached by discs or suckers to the bark of the root of the foster plant (in this case either white oak or witch hazel,) but also are implanted upon each other, forming parasitical anastomoses. I trust that Mr. Stauffer will continue these researches, and will publish the results, illustrated by his drawings.

Art. XXVIII.—*Reviews and Abstracts in Anatomy and Physiology;* by Dr. Waldo I. Burnett.

I. *Anatomy of the Nervous System of Rana pipiens.* By Jeffries Wyman, M.D. Smithsonian Contributions to Knowledge. pp. 51, 2 plates. March, 1853.

This is one of the few Monographs upon special anatomy that have appeared in this country. The Monograph belongs to the highest class of descriptive science: it is the handling of a subject in all its special details, and as though it were, at the time, *the* grand one for consideration. Philosophical science in its highest form can proceed only from scientific monographs, for the philosophical relations of any science are correctly understood only when resting on full and complete data.

Prof. Wyman's memoir contains many entirely new anatomical details, and is replete with sound, philosophical remarks on the homological and other relations of the vertebrate nervous centres.

Where there is so much worthy of special notice, we must be content to indicate a few of the principal features.

After pointing out some of the anatomical relations of the olfactory lobes, Prof. Wyman remarks:

"A condition of things rarely met with, perhaps only in a few Anourous Batrachians, is the fusion of the right and left olfactory

masses, with scarce a trace of any indication that they are double organs. . . . . This union of the olfactory lobes, however, is analogous to what occurs in the cerebral lobes of sharks and other Plagiostome fishes, and in the optic lobes of the *Lepidosiren*, and, as it seems, in *Menobranchus*. Their fusion is a subject of additional interest, since it tends to show that they are developed from a single embryonic vesicle, and not from a pair of vesicles. If this statement be true, then we have the olfactory lobes arrested in their development, previous to the division of this vesicle. An analogous state of things is easily shown in a chick of the fourth day, where the optic lobes form a single vesicle, though they subsequently become double and widely separated from each other. In *Lepidosiren*, according to Owen, there is but one optic lobe, and that on the median line; we may therefore regard this last as the vesicle undivided. The fusion, or rather the absence of separation, of the cerebral lobes of Plagiostome fishes, is undoubtedly to be explained in the same manner."—pp. 7, 8.

In speaking of the cerebral lobes, their distinct separation here is forcibly dwelt upon as an interesting anatomical feature, as connected with the complete duality of the function of these parts; and the opening through the brain downwards, which is made by the closing up of the fissure between the cerebral lobes, might seem at first comparable to the œsophageal ring of the invertebrates. Prof. Wyman here improves the excellent opportunity for some very sound remarks on the real grounds of an homology between the nervous centres of the vertebrate and articulate divisions of animals. He says:

"Although frequent attempts have been made to homologize the nervous systems of vertebrates and articulates, yet in reality there seems to exist no correct basis on which the alleged homology may rest."

After noticing the advocates of this view, and some of their grounds, he continues:

"If there be any homology, it seems to us as if the whole nervous system of the articulates, as far as it is developed, should be homologous with a corresponding portion of that of the vertebrates. If the subœsophageal ganglion is homologous with the medulla oblongata, that which follows it should be homologous with the spinal cord. . . . . If a true homology existed, we ought at least to have representatives from the articulates and vertebrates, in which the identity would be obviously proximate, if not absolute. But as yet, there has been described no instance where the spinal cord, structurally considered, is fairly and distinctly represented in the articulates, nor among vertebrates any true ganglionic chain with an œsophageal ring through which the œsophagus passes."—p. 9.

These doctrines of homology, with different divisions of the animal kingdom, demand the fullest attention from anatomists and physiologists, for our most comprehensive ideas of organization, and our highest views of the nature and permanency of grand types in animal life, depend upon our discrimination carefully between what constitutes a true homology, and what is merely a similarity of functional relations. In former times the writer, following Rathke and Geoffroy St. Hillaire, was the advocate, from embryological data, of this alleged homology between the nervous centres of these two grand divisions of the animal kingdom. Subsequently, however, extended and enlarged views of the character of grand typical forms, have shown the inadmissibility of such doctrine, and we are pleased to find here so clear an exposition of the real character of this hypothesis.*

Passing over the details of the description of the cerebral centres, and meeting our author at the cerebellum, we find some very noticeable remarks upon that disputed point, the function of this organ. He says:

"The low degree of the development of the cerebellum in frogs, naturally suggests to us an inquiry as to the nature of its functions, and likewise leads to the conclusion, that, whatever those functions are, they must, on analogical grounds, be supposed to have a low state of activity in comparison with the same organ in those animals in which it is proportionately more largely developed. The low development of this organ in frogs and cyclostome fishes is certainly at variance with either the more generally received theories entertained by physiologists of the present time; namely, those of Gall and Spurzheim on the one hand, and of Flourens on the other. It would be difficult to reconcile either of them, or perhaps any existing theory with numerous other facts afforded by comparative anatomy, all of which tend to show a vast disproportion, at least, between the size of the cerebellum and the activity of the functions of which it is alleged to be the seat. As regards the theory of sexual instinct, this function is certainly not less strongly manifested in the lamprey than in ordinary fishes, as the trout or the herring; yet how widely different is the relative size of the organ in the two."

Speaking of the theory of Flourens, Dr. Wyman says:

"His theory, that the cerebellum coördinates muscular motions, is opposed by numerous anatomical facts, as well as by some of the results of pathology; for out of *ninety-three* cases of lesions of the cerebellum, Audral found but *one* to sustain the theory of Flourens. . . . . We will take one more illustration

* It may not be out of place to mention in this connection a work which is well deserving the attention of all philosophical anatomists as to the point in question; viz., Observationes de prima Insectorum genesi adjecta articulatorum evolutionis cum vertebratorum comparatione, Diss. Inaug. By *Albert Kölliker*, Turin, 1842.

of the inconsistency of this theory (and it equally applies to that of Gall and Spurzheim) with facts; we will contrast the organ in question, as it appeared to us in the recent dissection of a porpoise (*Delphinus phocæna*) and of a shark (*Carcharias obscurus*). Both of these animals are predacious, both pursue their prey in the water, both are endowed with great rapidity of motion, both are capable of readily and suddenly changing their direction, and both move by the alternate flexion and extension of the vertebral column; I know of no reason for supposing that the power of coördination is materially different in the two; and in these instances the mass of the body was in the two nearly the same, and yet the cerebellum of the porpoise is not only relatively, but absolutely, several times larger than the whole encephalon of any other fish whatever."—pp. 13, 14.

No doctrine was ever received more kindly, or treated more justly by scientific men, than that of phrenology in its day. It is true that the pretensions and premises on which it was urged, were of a much higher character than those of other doctrines introduced to the public; but these had a speciousness, since there were arrayed for their support *some* facts in comparative anatomy, whereas the case appears quite different when *all* the facts with their relative bearings are studied. The sexual function of the cerebellun has always been considered one of the strongest points in the system of Gall; and as for the geography (so to speak) of the cerebrum, what reflective medical student is there, who has had an opportunity to open half a dozen heads and to dissect the brain, who has not seen the striking irrelevancy of the whole doctrine to facts; we refer here to the pretended organs on the brain's surface being evinced by corresponding prominences on the cranium. The allotment of certain portions of the brain for the performance of certain classes of mental action, is another thing; but even this is without that comprehensive support which could entitle it to a scientific character.

From the anatomical description of the grosser parts of the encephalon, Prof. Wyman proceeds to a consideration of the intimate anatomical structure of the brain as elucidated by microscopical inquiry. In this subject are involved points of the highest physiological import, and about which some of our best observers are very far from being agreed. As this is a subject to which the writer has paid some special attention of late, and moreover as his own results quite accord with those of Prof. Wyman, he will discuss the points freely in his own language.

Many details connected with the intimate composition of nervous tissues have long been satisfactorily settled by microscopists. It is no longer disputable as to the variety of the forms these elements take, neither is it a question as to their cell-composition. All nervous tissue has but two elements, the vesicular or genera-

tive, the tubular or conductive. The former composes the grey substance of the ganglia or nervous centres, the latter forms their medullary portion and the nerves. The question at issue of late among microscopical anatomists, is, what is the precise anatomical relationship between these two portions of nervous matter. Do the primitive nervous fibres enter the grey matter, wind about among the nerve-cells and ganglionic globules, and finally terminate in looping anastomoses, as has been advocated by our earlier observers; or do these primitive fibres terminate infundibuliform in ganglionic vesicles, as has recently been advanced by some of our best microscopical observers?

The decision of this point is important in connection with the origin and transmission of nervous force.

We will refer briefly to the historical relations of this subject. Many years since, Remak discovered in the nervous tissue, large vesicular bodies which had irregular digital prolongations. These prolongations he maintained were continuous into the grey fibres of the nervous substance. This view was soon after verified by Hannover, who after some extended research, concluded that the nervous centres contained two kinds of ganglionic vesicles, those which were simply spheroidal, and those which had processes which were continuous with the nerve fibres. Since then there have followed not a few observers with results of a similar import, and whose names we have indicated below.* Chief among these,

* For the sake of convenience of future reference, we here give the names of those observers who have studied this subject.

Remak, Observ. anat. micros. de Syst. nerv. Struct. Berlin, 1838; also in *Müller's* Arch. 1843, p. 200.
Hannover, *Müller's* Arch. 1840, p. 555; also Recherch. micr. sur le Syst. nerveux 1844, p. 69, Pl. VIII.
Helmholtz, De fabr. Syst. nerv. evertebr. Berlin, 1842, p. 10.
Will, *Müller's* Arch. 1844, p. 76.
Kölliker, Die Selbständigkeit und Abhändigkeit des sympathischen Nervensystems, 1844; also "Neurologische Bemerkungen," in *Siebold & Kölliker's*, Zeitsch. f. Zool., i, 1849, p. 135; also "Microscopische Anatomie," ii, 1850, p. 390–546.
Todd & Bowman, Physiological Anatomy, 1845, i, p. 212.
Volkmann, *Wagner's* Handwörterb. d. Phys., ii, p. 613.
Budge, *Roser* and *Wunderlich's* Vierteljahrsch. 1846, p. 347.
Hyrtl, Anatomie, p. 121.
Bardeleben, *Müller's* Arch. 1846, Jahresb. p. 84.
Schiff, *Griesinger's* Arch. 1846, p. 794.
Bendz, Almindel. Anat. p. 427.
Schwann, Ann. des Sc. Natur., 1846, vi, Pl. VI, VII.
Bidder u. Volkmann, Zur Lehre v. d. Verhältniss d. Ganglien-körper zu d. Nerven-fasern, 1847.

Reference may be also made to the following where the subject is incidentally, or in course illustrated.

Bruch, Ueber das Nervenssystem des Blutegels, in *Siebold u. Kölliker's* Zeitsch. f. Zool., i, 1849, p. 164, Taf. xii.
Leydig, Anat. Bemerk. üb. Carinaria, Firola und Amphicora, Ibid. iii, 1851, p. 325, Taf., ix, fig. 5.
Müller, Physiology, Transl. by *Jourdan*, *Littre's* Ed., Paris, 1851, i, p. 560, where also *Robin's* views are quoted.

however, as will be seen, is *Kölliker*. Judging from his statements and his still more numerous figures, there would appear no doubt that nerve-fibres may and do arise from the vesicular centres. (See especially the numerous figures in his "Mikroscopische Anatomie," ii, p. 390–546.)

After the most careful study of the intimate structure of the nervous centres of frogs, Prof. Wyman has failed to observe any thing of this direct anatomical relationship between the two portions of nervous substance. Liedy's observations on the microscopical structure of the nervous centres of the terrestrial Gasteropoda, sustain also the view of the non-direct connection. (See "The terrestrial air-breathing Mollusks of the United States, by Amos Binney. Edited by Dr. A. A. Gould. Special Anatomy, by *Leidy*, vol. i, p. 243.) To this the writer may add his own experience of the same import. He has invariably failed to detect the direct continuity of these parts, and in some special researches made sometime since on the intimate structure of the human brain, nothing of the kind warranting *Kölliker's* opinions was observed.

This discrepancy of results is not a little remarkable, and although from the character and the amount of the authority in favor of the direct connection of vesicles with nerve tubes, there can be no reasonable doubt that such relations do occur; yet it may be very justly asked if this connection when present, is not the exceptional condition, and one wholly unessential to the mutual physiological relations of the nerve-cells and nerve-tubes. If it is necesssary for the transmission of nervous power, that the nerve-tube should be directly continuous into the nerve-cell or vesicle, then it would be supposed that all nerve-fibres must terminate in this manner. This, as is well known, is not the case.

The writer has had the good fortune to be able to watch the phases of nerve formation from the earliest point to the complete condition, and it has occurred to him that these curious phenomena in question, might find some explanation in the probability of some of the old nuclei of the nerve formation, producing a cell within the confines of the nerve tube, and thus giving rise to a vesicular expansion. Some appearances have been observed rather favoring this view, but we adduce it only in a suggestive light. The whole subject deserves special attention from our best microscopical observers in anatomy.

From a consideration of the intimate structure of nervous tissue, our author passes to Section III, on the spinal cord. Space allows us to make but a single extract which we select upon a point of more general interest.

"The change of form which the spinal cord undergoes during the progress of development is one of the most interesting features, and one which long since attracted attention. The phases

are the same that are met with in other vertrebrates in which limbs are developed; but while in these the changes take place with great rapidity, in frogs generally the ichthyic condition of the cord in which there are no enlargements or bulgings, continues for several months, the eggs being hatched in the spring, and the complete development taking place in the latter part of the summer. In bull-frogs, in this latitude at least, (42° north), it took not less than a year, as the tadpoles hatched in the spring, pass the following winter in the same condition, the metamorphosis occurring during the following spring or summer.

Until the legs begin to be developed, the cord presents the form of an extremely elongated cone, and the bulgings as was noticed by Serres, are developed simultaneously with the legs. I have not, however, been able to confirm the statement made by him, and repeated by others, that the caudal portion of the cord is shortened as the legs and the bulgings are developed. According to my observations, no shortening takes place until the absorption of the tail commences, and this happens after the bulgings are formed and the legs have acquired their growth. The whole of the caudal prolongation, however, is not absorbed, a portion being persistent and eventually becoming enveloped by the elongated coccyx."—p. 21–22.

Section IV, treats of the peripheral portion of the nervous system. Here Prof. Wyman's researches have afforded results somewhat different from those of his predecessors.

The subject of the cranial nerves is, as is well known, one of the most important connected with philosophical anatomy; for upon the interpretation of these nerves, depend the various cranial theories some of which have become so noted. We cannot better present the subject than by giving Prof. Wyman's table which exhibits an enumeration of the cranial nerves of man and mammals compared with those of the frog.

"A. Cranial nerves.

Mammals.		Frog.
I. Olfactory,		I. Olfactory.
II. Optic,		II. Optic.
III. Motor communis,		III. Motor communis.
IV. Patheticus,		IV. Patheticus.
V. Trigeminus, VI. Abducens, VII. Facial,	are combined, and form	V. Trigeminus.
VIII. Auditory,		VI. Auditory.
IX. Glosso-pharyngeal, X. Vagus, XI. Acessory, XII. Hypoglossal,	comb'd & form	VI. Vagus.

B. Spinal nerves of the Frog.

I. Hypoglossal.		VII.	Crural.
II.	Brachial.	VIII.	
III.		IX.	
IV.	Abdominal.	X. Coccygeal.	
V.			
VI.			

From this table it will be seen that the hypoglossal nerve in the frog occupies a position somewhat anomalous, forming, as it does, the first pair of the spinal series."—p. 24.

In his description of the optic nerves, Prof. Wyman has some interesting remarks on the relations of the optic lobes to the function of vision. He says: "Many observers have shown, by dissection, that blindness of long standing is followed by atrophy of the optic lobes, (agreeably to the well-known law of atrophy following disuse), and that extensive lesions of the lobes are attended by either impairment or loss of vision. In recent dissections of frogs, similar results have been observed. One in which the *right* eye had been destroyed had atrophy of the left lobe, which was reduced by nearly one-third of the dimensions of that of the opposite side. The condition of the nerve was not examined.

In a second instance, there was blindness from destruction of the left eye, in which there was atrophy of the left nerve before decussation, of the right nerve behind the decussation, and of the right optic lobe. In neither of these cases was there any marked alteration in the proportions of the optic thalami." But he adds: "The facts furnished by comparative anatomy, however, tend to show that vision is not the sole function of the optic lobes." He then alludes to the instances of blind animals found in caverns and other dark places, in which the optic lobes are not undeveloped. But we do not recognize the correctness of this last sentence, and cannot perceive how the plural function of these lobes can be inferred from the data cited. On the other hand, considering the stability of typical forms in structure, and the unvarying relations of grand types, even in distinct systems of tissue, we should indeed not look for any deviations from these fundamental plans to fit a single condition, and especially where all the other relations of life are as usual. The doctrine of final causes, although fully sustained by the general conditions of organization as manifested under typical plans, has many an instance in living forms which would be wholly irreconcilable, did we not bear in mind its reference to a type idea. The mammary gland exists in man as well as in woman, and yet it has but one function, its presence in man being in virtue of a typical plan.

We pass over the details upon the cranial nerves contained in this section. Not a few of them are new, and the whole carried out in all their relations with an almost wonderful minuteness.

We would not omit, however, to notice the discovery which Prof. Wyman has made of a new nerve with the Batrachian reptiles. It is a nerve strictly identical with the *nervus dorsalis* of fishes. It is a branch from the *nervus lateralis* and appears to have been hitherto unnoticed. Prof. Wyman remarks:

"The observation of the existence of a dorsal nerve gives additional importance to the discovery of the nervus lateralis by Van Deen; and if to these we add those branches of the vagus described above, which pass along the branchial arches, the analogy of the larvæ of Batrachians to fishes becomes much more striking than there has been reason hitherto to regard it."—p. 37.

Section V. treats of the philosophical anatomy of the cranial nerves and skull. *Prof. Wyman* gives his preference to the three vertebræ theory of the constitution of the cranium. He says:

"If we apply the analogies of the spinal chord and vertebral column to the cranium and its nerves, we ought to base our determinations on the repetitions of true spinal nerves and of the true vertebral elements. If the theory be true which reduces the cranial nerves (exclusive of the special sense nerves) to three, namely, the trigeminus, vagus, and hypoglossus, then we ought, *à priori*, to detect at least three vertebral segments. This conclusion agrees perfectly well with the determination from osteology. . . . . These vertebræ may be designated as follows: 1st, the occipital, of which the basilar bone is the body; 2nd, the parietal, of which the posterior sphenoid is the body; 3d, the frontal, of which the anterior sphenoid is the body."—p. 41.

In concluding this section, Prof. Wyman has some very noticeable remarks on the interpretation to be given to the jaws and other bones of the face in connection with the three vertebræ theory. After alluding to the fact that the latter are strictly appendages of the mucous membrane, and that the jaws and other tooth-bearing bones, as well also as the hyoid bone, are developed in intimate relation with the alimentary canal, and that primarily the mouth and nostrils are but a single cavity, he remarks: "We have strong grounds for the hypothesis, that all the bones of the face which are developed in the walls of the primitive cavity of the mouth which they surround, are in their anatomical and physiological relations splanchnic, connected either with digestion or respiration, rather than parts of the endo-skeleton of animal life."—p. 42.

The last two sections (VI and VII) treat respectively of the spinal nerves and of the sympathetic nerve. They are full of details most interesting to the thorough anatomist; but our space will not allow us to refer to them specially. It should be mentioned, however, that Prof. Wyman has distinctly made out a coccygeal nerve, thus making the number of pairs of spinal nerves ten instead of nine, the number usually enumerated; and

also showing that the strangely shaped coccyx is a true vertebra. We have thus but imperfectly indicated the contents of the work under notice. It could scarcely be otherwise, for the various subjects in the different sections are treated so connectively from paragraph to paragraph, that full justice to the author's labor could be given only by making longer quotations than our space would admit. However, the purpose of this notice will be accomplished if we succeed in calling attention to one of the ablest of recent researches.

II. *The Hectocotylus of the Cephalopoda.*

Delle Chiaje, Memoria sulla Storia et Notomia degli animali senza vertebre del regno di Napoli, 1825, p. 223, Tav. xvi, fig. 1-2.
Cuvier, Ann. des Sc. Nat. xviii, 1829, p. 147, Pl. xi, A. fig. 1-5.
Costa, Ann. des Sc. Nat. 1837, p. 172, also Ibid. 1841. xvi, p. 184, Pl. 13, fig. 2, a-c.
Kölliker, Annals Nat. Hist., xvi, 1845, p. 414, also, Bericht von der zootomischen Anstalt zu Würtzburg, Leipzig, 1849. p. 67, Taf. i, ii; and Transact. Linn. Soc., xx, 1846. Pl. I, p. 9.
Siebold, Lehrbuch der vergleichenden Anatomie der wirbellosen Thiere. Berlin, 1848, p. 362. Also Zeitsch. für wissensch. Zool., iv, p. 122.
Power, (Madame,) Mollusques Mediterranéens. 1ere Partie. Gènes, 1847-51, p. 34, and 126. Pl. xli.
Vêrany & Vogt, Ann. des Sc. Nat. xvii, 1852, p. 146. Pl. vi-ix.
H. Müller, Ann. des Sc. Nat., 1852, xvi, p. 132, Also, *in extenso* in the Zeitsch. für wissenschaftl. Zool., iv. p. 1, Taf. i, and p. 346.

The Hectocotylus is a worm-like form which is found attached like a parasite to certain forms of Cephalopoda, (*Octopus*, *Tremoctopus*, *Argonauta*.) The subject has attracted so much attention from its curious nature that I have thought best to indicate its historical relations by the above list of authors and papers. They will, moreover, serve as texts to some little account of this zoological anomaly.

These bodies in question, which are vermiform, but which resemble distinctly no animal whatever, are found attached by a sucker, in the cavity of the mantle of certain cephalopods. It is not strange that some of the observers first named should have regarded them as parasitic worms, and although presenting evidently, anomalous anatomical parts, Cuvier concluded by pronouncing it "un ver vraiment extraordinaire."

But it soon appeared as a remarkable fact that the cephalopods on which these bodies were found were invariably of a certain kind, and furthermore, that from the most careful search, no males were seen. From this, Kölliker was led to regard them as male cephalopods of a remarkable nature. This supposition was confirmed by his anatomical researches, for he showed that the structure of these forms had, in many respects the characteristics of the cephalopods alone; besides containing distinct spermatic and fecundating parts. It was then evident that these curious bodies were of a true cephalopod nature and served the function of males. But it was a question of both physiological and

zoological import, what is their individual character. Are they to be regarded as distinct animals, having an independent existence; or are they simply cephalopods in which a male apparatus is developed. The settling of this question was attended with more difficulties than would have been supposed, and it provoked the labored, accurate and detailed researches of the few last-mentioned memoirs in the preceding list. The first of these views, namely, that these forms are truly independent animals, has been supported by Kölliker, who, in a very extended memoir, has attempted to show that, having a heart with the vessels, and possessing also branchial nerves and such highly developed genital organs, they can be regarded only as distinct individuals. Moreover, he brings to the support of his view the observations of Madame Power, and of Maravigno, from which it would appear that the hectocotyli are formed within eggs, and first appear as small worms having two rows of suckers on their whole length, and a filiform appendage at one extremity, and a small enlargement at the other.

On the other hand, other and later observers support the second view, the non-independent animal character of these forms. Chief among these are H. Müller, and Vérany & Vogt, and incontrovertible as would seem at first the ground of Kölliker's opinion, they have satisfactorily shown, even to Kölliker himself,* the correctness of their position. The details of these researches by which the question seems now pretty definitely settled, the limits of these pages will not allow me to give. It may be remarked, however, that these observers have all studied these forms upon living specimens on the coast. It has been shown that the Argonauts on which these hectocotyli are found, have a highly developed testicle, the situation and structure of which correspond to those of the common cephalopods, and which communicates with the hectocotyle.

In conclusion, I may quote H. Müller's own words: "It is then proved that the hectocotylus is formed on a male argonaut, and is nothing but an arm metamorphosed in a very irregular manner. This arm, or the hectocotylus, is detached when it has been filled with the sperm which is formed in a true testicle of the argonaut itself, and it then plays an apparently independent life. In this condition, it meets the female argonauts which form a true copulation, it impregnates, as I have observed with the hectocotylus of a *Tremoctopus*, and it resembles in this, as also, by its movements, by a kind of circulation, and by the long duration of its life after detachment, a true male animal."

* See the *Nachwort*, by *Kölliker*, to the memoir by *H. Müller* in the Zeitsch. für wissenschaftl. Zool., iv, p. 35.

III. *New Muscle-element in the Thoracic Muscles of Insects.*

*Aubert** states that he has found an entirely new form of muscle-element in the *Libellulidæ;* this consists of flat, primitive, muscular bands occurring only in the thorax, and which by means of a pitcher-shaped (becherförmigen) apparatus, move the wings.

The following are his conclusions on this subject:

"1. The comparatively very large muscles of those insects which fly with a buzzing sound, separate, when fresh, into fine, transversely striated fibres.

2. The fibres are the primitive muscular fibrillæ.

3. Between the fibrillæ there is a granular mass, the use of which is unknown.

4. All other muscles when fresh present no appearances of this kind.

5. The *Libellulidæ* have in the thorax primitive muscular bands.

6. The elements of the muscles are little cakes or cylinders which are applied together, forming the fibrillæ.

7. During contraction, the fibrillæ thicken, and the striæ are approximated."

These results have been confirmed by my own experience, for the thoracic muscles of insects have long been to me beautiful objects for the study of the histological elements of muscular tissues. It is a form of this tissue particularly to be recommended for the study of the intimate sarcous elements. The fibrillæ readily separate into the discs of which they are composed, and the whole field is then filled with these last floating freely about. But it is a question if these primitive fibrillæ which are here so distinct, are not the products of definite cleavages of primitive muscular fibres. In studying them carefully with a power of 800 to 1000, we have been able to detect no remains of their early formative conditions. Furthermore, we know that the muscular fibre is the primitive embryological element of this tissue. It therefore appears to us probable that this peculiarity of the thoracic muscles of insects is due simply to readiness for cleavage, and which may be subservient to their rapid and delicate action.

Another point which we have noticed, and which Aubert also has alluded to, is the singular spiral aspect which these fibrillæ sometimes assume from an apparently irregular movement in their contraction. This is particularly worthy of note now, since, recently, Martin Barry (*Müller's* Arch. 1850, p. 529) has advanced the doctrine of the spiral structure of muscular fibrillæ. We have not critically examined the ground on which Barry has based

* Ueber die eigenthümliche Structur der Thoraxmuskeln der Insekten, in *Siebold & Kölliker's* Zeitsch. für Zool. iv, 1853, p. 388, Taf. xv.

his views, but from our knowledge of this tissue, the phases of its formation from the earliest to the perfect state, and the various appearances it presents in different parts of the animal kingdom, we are led to venture the conjecture that its alleged spiral structure, may be due to irregularities and anomalies of contraction.

IV. *On the presence of a layer of transversely striated muscular fibres in the Choroidea of Birds.*

The presence of this form of tissue in this locality has recently been announced by Wittich,* and the subject is of so much interest from some physiological bearings, that it deserves a special mention. It may not, perhaps, be remembered that two or three years since, Rainey† announced that he had discovered striated muscular fibres in the posterior portion of the choroidea of the eyes of mammals. This anatomical contribution of great importance in the physiology of the eye, if true, was verified to a certain extent by Henle; but Wittich has been unable to observe any such structure in the Ruminantia, Rodentia, and Carnivora, and in man; he has, however, contrary to the statements of Rainey, detected this tissue in the whole posterior half of the choroidea of birds. As to the manipulation and preparation for the observation of this tissue, I will quote Wittich's own words:

"For the most intimate research, I can best recommend the eye of the thrush. This having lain a short time in diluted alcohol, not only the retina, but also its subjacent membrana pigmenti can be entirely removed. This being done, the choroidea can be removed from the sclerotica and spread out on a plate of glass; here its external tunic containing the vasa vorticosa is to be separated from it. Between this external tunic and the membrana pigmenti there is a layer which usually can be completely isolated; this layer is pretty clear, transparent, and contains throughout only a few of the star-like pigment cells which belong to the choroidea; in it may be easily seen an open net-work, composed of muscular bundles, arranged in an interlacing, and often a radiating manner. The bundles are slightly yellowish, but their contours are sharp from the action of the spirit, and the transverse striæ are boldly prominent. The separate bundles become pretty attenuated, and in this way disappear in the connecting tissue which forms the basis of the whole layer. They disappear towards the ciliary border, the meshes becoming more open, but they are most numerous towards the pecten of the choroidea.

* *Siebold & Kölliker's* Zeitsch. f. wissenschaftl. Zool. IV. p. 456, Apr. 1853.

† "Description of a muscle of the striated variety, situated at the posterior part of the choroid coat of the eye in Mammals, with an explanation of its mode of action in adapting the eye to distinct vision at different distances." By *Geo. Rainey*, Proceed. Roy. Soc. 1851, Jan., p. 23.

Rainey regards this choroid muscle as the analogue of the ciliary muscle of birds, a view which, *Wittich* shows to be unfounded.

The thickness of the primitive bundles corresponds exactly to that of Crampton's muscle. This muscular layer is less easily observed with the eyes of doves, hens, turkeys, geese, ducks and crows, owing to the greater number of pigment cells in the choroidea, and to the greater disposition of the primitive muscular bundles to split up into the fibrillæ, which have a varicose aspect, and are almost exclusively seen in prepared specimens."

As to the function of this muscular layer, Wittich remarks: "Its action would contract the choroidea, thereby diminishing its concavity, and at the same time move the vitreous humor and the lens forward; the pressure on the vasa vorticosa being lessened these would be filled with blood, while the processus ciliares would be diminished from the increased pressure upon them of the aqueous humor. The whole mode of life of the birds, the sudden movements which they make, from which it is necessary that their eyes shall act over the most variable distances, all require the existence of a very complex and delicate muscular apparatus." He then alludes to the well-known relations of *Crampton's* muscle and of the pecten; in the same category with which belongs the muscular tissue in question.

Wittich's concluding remarks may well be quoted: "I will here mention a circumstance which seems to me well worthy of especial attention in comparative anatomy, but which unfortunately I have been unable to follow out thoroughly. It is, that with some birds there is a considerable thickening of the outer vascular layer of the sclerotica, which, in the eyes of geese and ducks, is composed of a peculiar arrangement of the blood-vessels like the choroidal glands in fishes. In fishes, as well also as in the amphibia I have examined, I have seen no muscular layer of the choroidea; but in the eye of *Cyprinus erythrophthalmus* and *carpio*, there are many delicate, ribband-like, slightly attenuated forms, which, in their general aspect, and their behavior in acetic acid, closely resemble the cells of smooth muscular fibre. Moreover, their relative situation to the parts is the same as the muscular bundles of the choroidea of birds just described."

These observations of *Wittich* are of more importance than would at first appear; for, aside from the presence of this muscular layer which he has discovered, the existence of *Crampton's* muscle has been disputed by some anatomists (see *Huck*, Die Bewegung der Krystallense, Leipzig, 1841); but now, from the investigations of our author, which so completely confirm those of Treviranus, Crampton, and Krohn, the case admits of little doubt.

The striated, and therefore voluntary character of this whole system of muscular apparatus is especially worthy of note in connection with the eminently adaptive power it gives to the eyes of these animals.

V. *On the seat of the Sugar formation in the Animal Body.**

As is well known, *Bernard* (Compt. Rend. xxxi, p. 572, 573,) has shown the existence of sugar in the liver, not only of all vertebrates, but also in that of the Gasteropoda, Acephala, and Decapods. *Frerichs* (Article, *Verdauung* in *R. Wagner's* Handwörterb, d. Physiol. p. 831,) has confirmed these observations for the liver of man, and many animals; *Van den Broek* (Nederlandsch Lancet, p. 108–110) for that of dogs and rabbits; *Baumert* (*Erdmann's* Journal, liv, p. 359) for that of the fox, the dog, the cat, and the sheep; and *Kunde* and *Lehmann* (*Kunde*, De Hepatis ranarum exstirpatione, Diss. Berolini, 1850, p. 11) for that of frogs.

I selected twelve frogs for my investigations, (says Dr. Moleschott,) and notwithstanding the smallness of their livers, so much sugar appeared that it was easily shown by Trommei's test. Bernard and Lehmann regard this sugar of the liver as grape-sugar.

The question arises, is this sugar of the liver derived from the blood, or is it formed by the liver proper? Bernard advocates the latter view, since he has thus obtained the sugar wholly independent of the food, with the Carnivora and Herbivora, with animals famished during hibernation, and with the fœtus in utero. Frerichs, Van den Broek, and Baumert, have repeated these observations and confirmed them.

Still more important is the result obtained by Bernard (loc. cit.) and Lehmann (*Erdmann's* Journal liii, p. 214, 215) that the partal blood of the dog and horse contain little or no sugar, while the blood of the hepatic vein contains, like no other vein in the body, this substance in considerable quantity.

To these data I would add a fact of some import. If the sugar is not found in the liver, but is only strained off, as it were, by this last from the blood, then the blood of those animals whose liver had been removed would be found surcharged with sugar, exactly as the blood is filled with urea in animals whose kidneys have been removed. But with frogs, some of which had been without the liver for fourteen days, others for three weeks, I found no sugar in the blood, flesh, gastric juice, urine, nor finally in the water in which twenty-six of these animals thus mutilated had passed two days.

From all these facts it appears to me indubitable that the sugar contained in the liver is formed by the liver itself.

* Translated from *Müller's* Arch. 1853, March, p. 86.
(Ueber die Bildungstätte des Zuckers im Thierkörper. By *Dr. Jac. Moleschott.*)

A list of the Works and Articles upon Anatomy and Physiology published since 1853, *which have come under our notice.*

As some of the Continental works of the latter part of 1852, of great importance, did not reach us until this year, we have included them in our list.

This list commencing thus with 1853, will be continued in each No. of the Journal and will be made as complete as our means will allow.*

1. SPECIAL WORKS.

Beiträge zur mikroskopischen Anatomie und Entwickelungsgeschichte der Rochen und Haie; von Dr. Franz Leydig. Leipzig, 1852.

Anatomisch-histologische Untersuchungen über Fische und Reptilien; by the same. Berlin, 1853.

[These works of *Leydig* are of the first order, and their microscopic details are illustrated with many excellent figures. We shall have occasion to refer to them particularly hereafter.]

Entwickelungsgeschichte des Meerschweinchens; von Th. Ludw. Wilh. Bischoff. Giessen, 1852.

A Text Book of Physiology; by Dr. G. Valentin. Translated and edited from the 3d German edit. by William Brinton, M.D. London, 1853.

The Dissector's Manual of Practical and Surgical Anatomy; by Grannus Wilson, F.R.S. London, 1853.

2. PERIODICAL LITERATURE.

Siebold & Kölliker's ZEITSCHRIFT FÜR WISSENSCHAFTLICHE ZOOLOGIE. Band iv, Heft. 3, 4. April, 1853.

[This Journal which, in the department of Physiology and minute Anatomy, has no equal anywhere, we shall frequently draw from in making our selections. Where all is so interesting, we cannot do otherwise than present the contents of this No. in tabular form.]

Cohn, Beiträge zur Entwickelungsgeschichte der Infusoria.
Bruch, Beiträge zur Anatomie und Physiologie der Dünndarmschleimhaut.
Gegenbaur, Kölliker & H. Müller, Bericht über einige im Herbste 1852 in Messina augestellte vergleichendanatomische Untersuchungen:
Kölliker, Entwickelung von *Tubularia* und *Campanularia*.
—— über Siphonophoren.
—— über Rippenquallen.
—— über Scheibenquallen.
—— neuer Schmarotzer, Lophoura.
—— Bau von *Leptocephalus* und *Helmichthys*.
—— Sigenthümliche Hautorgane und Wirbel von *Chauliodus*.
Gegenbaur, Entwickelung der Echinodermen.
—— Bau der Heteropoden und Pteropoden.
H. Müller, Ueber Salpen.
—— Bau der Phyllirrhoe.
—— Bau der Cephalopoden.
—— Ueber die Hectocotylen.
Kölliker & Gegenbaur, Entwickelung von Pneumodermon.
Kölliker & H. Müller, Chromatophoren bei *Cymbulia*.

* We are under grateful obligations to *Prof. Agassiz* who has afforded us invaluable facilities in freely opening to us his rich and extensive library. Aside from constant purchases, this gentleman's eminent position causes his library to be well stocked with all new works in natural science.

Supplement.

Kölliker, Lüftlocher der Schale der Velelliden, Guanin bei *Porpita*.
Gegenbaur, Larve von Pneumodermon, Circulationsverhältnisse der Ptero- und Heteropoden, Entwickelung der Schiebenquallen u. von *Velella*.
Bruch, Ueber die Entwickelung der Clavicula und die Farbe des Blutes.
Leydig, Zoologische Notizen.
Aubert, Ueber die eigenthümliche Structur der Thoraxmuskeln der Insecten.
Siebold, Ueber die Verwandlung des *Cysticercus pisiformis* in *Taenia serrata*.
— Ueber die Verwandlung der Echinococcus-Brut in Taenien.
— Ueber *Leukochloridium paradoxum*.
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Smaller Communications and Correspondence.

Nordmann, Ueber *Tetrarhynchus*.
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Müller's Arch. für Anatomie, Physiologie und Wissenschaftliche Medicin, Heft. i, March.

J. Müller, Ueber die Semitae Spatangoiden.
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Meyer, Das aufrecte Stehen.
Schlemm, Ueber die Verstärkungsbänder am Schultergelenk.
Fick, Beitrag zur Mechanik des Gehens.
— Ueber die Architectur des Schädels der Cerebrospinal organismen.
Moleschott, Versuche zur Bestimmung der Rolle, welche Leber und Milz bei der Ruckbildung spielen.
— Ueber die Entwicklung der Blutkörperschen.
— Ueber die Bildungsstätte des Zuckers im Thierkörper.
Krohn, Ueber einige niedere Thiere.
Kohlrausch, Beiträge zur Kenntniss der Schilddrüse.

Annales des Sciences Naturelles, xix, 1853, No. 1.

Pontallei, Observations sur Lombrie terrestre.
Lacaze-Duthiers, Recherches sur l'armure génitale femelle des Insectes hémiptères.

Quarterly Journal of Microscopical Science.—[No. 1, of this valuable Journal, was published in October, 1852, but we record its articles that our list here may be complete.]

Huxley, Lacinularia Socialis. A contribution to the Anatomy and Physiology of Rotifera. p. 1 (of Transact. Microsc. Soc. Lond.)
Mummery, On the development of Tubularia indivisa. p. 28, (ibid.)
Williamson, On the Anatomy of Melicerta ringens. p. 1, and 65.
Lister, Observations on the contractile tissue of the Iris. p. 8.
Huxley. Observations on the existence of cellulose in the tunic of Ascidiens. p. 22.
Kolliker, Description of Actinophrys sol. (Transl.) p. 25 and 34.
Busk, Some Observations on the Structure and development of Volvox Globator, and its relations to other unicellular plants. p. 31. Transact. Microsc. Soc.
Williamson, Further Elucidations of the Structure of Volvox Globator. p. 45. Ibid.
Gosse, On the Structure, functions, habits and development of Melicerta ringens. p. 71.
Huxley. On the Development of the Teeth, and on the Nature and Import of Nasmyth's "Persistent Capsule." p. 149.
Gray, On the Teeth on the Tongues of Mollusca. p. 170.

[This Journal, of which we have seen the first three Nos., contains also translations of various interesting articles from the German and French Journals.]

The Annals of Natural History, vol. xi, January to July, 1853.

Hancock, On the Animal of *Chamostrea albida:* p. 106. On the animal of *Myochama anomiodes*. p. 287.

Cobbold, Observations on the Anatomy of Actinia. p. 121.
Owen, On the Anatomy of the Wart-Hog. (Proceed. Zool. Soc.) p. 246.
Lowe, On the Reproduction of the Frog and Toad without the intermediate stage of Tadpole. p. 341.
Huxley, On the identity of Structure of Plants and Animals.
Crisp, On some points relating to the structure and mechanism of the Wolf-fish (*Anarrhichas Lupus*). p. 463.
Turner, Note on the suborbital gland of the Nylghau. (Proceed. Zool. Soc.) p. 467.
Tomes, On the Structure of the teeth of the American and Indian Tapirs. (Ibid.) p. 472.
Jenyns, On the reproduction of Frogs and Toads without the intermediate stage of Tadpole. p. 482.
McDonald, Observations on the Anteunæ in a small species of Crustacean. p. 488.

Philosophical Transactions, 1852. [Received in 1853.]

Wharton Jones, Discovery that the Veins of the Bat's Wing (which are furnished with valves) are endowed with rythmical contractility, and that the onward flow of the blood is accelerated by each contraction. p. 131.
Hancock and *Embleton*, On the Anatomy of Doris. p. 207.
Gray, On the Development of the ductless glands of the Chick. p. 295.
Nelson, The reproduction of the Ascaris mystax. p. 563.
Williams, On the Blood proper and Chylaqueous fluid of Invertebrate Animals. p. 595.

The Transactions of the Linnæan Society, vol. xxi, p. 1.

Blackwall, Experiments and Observations on the poison of Animals of the order Araneidea.
Newport, The Anatomy and Development of certain Chalcididæ and Ichneumonidæ, compared with their Special Economy and Instincts; with descriptions of a new genus and species of Bee-parasites.
—— Further observations on the genus *Anthophorabia*.

Memoirs of the American Academy of Arts and Sciences. New Series, vol. v, Part 1, 1853.

Burnett, Researches on the Origin, Mode of Development, and Nature of the Spermatic particles among the four classes of the Animal Kingdom.

Smithsonian Contributions to Knowledge, vol. v, 1853.

Leidy, A Fauna and Flora within living Animals.
Wyman, Anatomy of the Nervous System of Rana pipiens.

The Proceedings of the Academy of Nat. Sci. Philadelphia, and of the Boston Soc. Nat. Hist., which contain constantly valuable contributions in Anatomy and Physiology, are given in full in another part of each No. of this Journal.

Art. XXIX.—*Correspondence of M. J. Nicklès, dated June* 30, 1853.

Chemical Researches on Dyeing.—In the ninth memoir of M. Chevreul on dyeing, communicated recently to the Academy of Sciences, this chemist takes up especially the subject of *the action* which solid bodies may exert, while preserving their condition, on a liquid holding in solution a solid body or a liquid—an action which he designates *capillary affinity*. This kind of phenomenon which has engaged the attention of this learned chemist for nearly half a century, has been observed by him in connection with the fixation of coloring substances which combine chemically with tissues.

After showing that several of the ingredients of mortars, such as gravel, the coarse sand of the Seine, burnt brick, etc., communicate to

the lime water a notable quantity of base, whilst, the limestone when put in a proper flask, loses equally a small proportion, M. Chevreul experiments on the subject under three points of view: to wit—

1. When the solution undergoes no change.
2. When it yields to the solid more water than of dissolved substances.
3. When it yields more of dissolved substances than water.

In the first case, are found, nitrate of baryta and chlorhydric acid, with wool; bichlorid of mercury with cotton. In the second, chlorid of sodium with wool, silk and cotton; alum, sulphuric acid, and nitrate of lead with cotton only: finally, chlorohydric acid, nitrate of baryta, with silk and cotton. In the third case, there are limewater and barytic water, which yield to the wool, silk or cotton, more of dissolved ingredients than water; and the same is true of sulphuric acid, bichlorid of mercury, alum and nitrate of lead, as regards both wool and silk.

But although cotton absorbs a solution of bichlorid of mercury in the proportions of the solution, and while it absorbs more of water than of alum, it is not less true, that it should have some affinity for the dissolved body; and M. Chevreul has observed, that after the most thorough washings, and when the water from the cotton dipped in the bichlorid of mercury, gives no longer a reaction with the salts of silver, the cotton itself is still colored black by sulphuretted hydrogen. In the same way, the cotton soaked in alum retains alum enough to become colored in the cold by infusion of cochineal, woad, logwood, and madder. Cotton dipped in nitrate of lead or nitrate of baryta, acts in the same manner.

All these results have some relation to the temperature at which the operation has taken place, and the length of time of the immersion of the tissues. This action of solids in destroying solutions, shows why it is often so difficult to wash certain precipitates, and how filters may act chemically on the liquids that pass through them.

This series of facts, to which belong also the decolorating and disfecting effect of carbon, and its action on solutions of the proximate principles, was published by M. Chevreul in 1809, and M. Tilloy of Dijon has founded on this action a process for extracting scillitine, and Lebourdais another for extracting the organic bases.

In the military bleaching establishment of St. Denis, where are bleached 6000 linen shirts per day, the fact has been fully recognized that the linen weakens promptly the alkaline lye, by taking up the alkali; and this is therefore, an example of the same kind with those treated of by M. Chevreul.

All these facts, which M. Chevreul groups under *capillary affinity*, have some applications even to physiology. For after observing that an organic tissue attacks a solution by appropriating one of its approximate principles present in larger proportion than another, we readily conceive that analogous effects may take place in the organic economy, without the necessity of recurring to vital action in order to explain the first cause of the fact. Water may permeate a membrane, a cellule, or a vessel, to the exclusion of a substance which it holds in solution, and this without any glandular apparatus. We comprehend how solutions which act on the organ of taste, or in the interior even of some organ, may produce some effects at a certain degree of concentration,

which disappear, or which are not produced when the proportion of water is more considerable.

The facts may explain the observation by Th. de Saussure, that the roots of plants placed in certain saline solutions absorb proportionally more of water than of the salts dissolved. M. Chevreul, moreover, shows this fact by a simple experiment, by putting into one of the branches of a curved tube a solution of common salt, and in the other, dry tissue, tendons, e. g., the tube being hermetically sealed; after some time a crystallization of the salt is seen above the level of the liquid.

Pisiculture.—M. de Quatrefages has communicated to the Academy some important researches bearing on different points connected with the artificial fecundation of the eggs of fishes. Assisted by M. Millet, of whom we have spoken in our last communication (p. 104 of this volume,) he has first shown that the temperature of the water for fecundation is a point deserving especial attention. This temperature varies for each species, and it is well to ascertain it for each separately. In general, for the winter fish, as trout, it is between 6° and 8° C.; for the early spring fishes, as pike, 8° to 10°.; for the later spring, as perch, 14° to 16° C.; and finally for the fishes of summer, as the barbel, 20° to 25° C.

The necessity of a specific temperature is connected also with the vitality of the spermatozoids of different species, which is of short duration, it not exceeding 8 minutes in the pike, whilst in man it lasts 8 hours. The maximum of vitality for the spermatozoids of the pike has been obtained at +2° C.; a higher temperature destroys them rapidly. The spawn of the pike is kept perfectly well in ice water, and the spermatozoids perish only with a cold below 10° or 12°.

This influence of temperature on the vitality of the spermatozoids of fishes, and therefore on the fecundation of eggs, presents a reason for the instinct which urges certain fishes to ascend streams, and at times to penetrate into rivulets where they have hardly water enough for their movements.

M. de Quatrefages deduces some rules which are important to the art of pisciculture, bearing especially upon the preservation of the spawn.

1. The water should not be supplied with the spawn in advance; it is well to leave the spawn in place even till the moment of employing it, and the fecundation should follow soon, upon the death of the male fish.

2. Since the fecundation should take place within a day or twelve hours after the death of the animal, the spawn should be then taken and kept separate.

3. To preserve the spawn, it should not be placed in the water, or in the open air, but better in a moist linen cloth, which is kept at a temperate equal to, or a little below that, which for each species gives the maximum duration to the movements of the spermatozoids.

4. If there are several fecundations to operate successively, it is necessary to detach for each, the quantity of spawn required, and leave the rest in some convenient place.

Over-heated Steam applied to the Carbonizing of Wood.—For several years past, over-heated steam has been used in numerous industrial operations, and we may say generally that it may be employed in all

processes in which a temperature between 100° and 500° C. is required. Among these processes, are the extraction of wood-spirit, the continuous baking of bread, the preparation of sea-biscuit, the drying of wood, the preservation of meats, the extraction of volatile substances insoluble in water, the purification of fatty acids, by MM. Leplay and Dubrunfaut, the extraction of the mercury from the residues of zinc amalgam, by M. Violette, and finally the carbonizing of wood by the same chemist.

M. Violette is a member of the Commission on Powder and Saltpeter and in this situation, he has turned his attention to the ingredients of powder, the manufacture of which still admits of much improvement. The charcoal employed in this manufacture is of a quality intermediate between wood and ordinary charcoal; it is called red charcoal (*charbon roux*,) and is produced at 300° C.; at a higher temperature it becomes black charcoal, and at a lower, the carbonization is incomplete.

By the old process of heating in closed cylinders, 10,000 kilogrammes of wood furnished 2000 kil. of black charcoal, and 1300 of red. The new process with steam yields a better article in larger quantity, for 10,000 kil. of wood, give 4000. The wood immersed in the vapor is readily carbonized, and as it is easy to regulate the temperature of the vapor, charcoal may be obtained of a constant and uniform character. It is some years since that over-heated steam was first adopted in this process, by M. Violette, and now the red charcoal, before employed only for the finest powder, is in general use for the cheaper kinds, so simple and certain is its preparation by means of steam.

M. Violette communicates now to the Academy some new results. He shows that the change to charcoal takes place differently with different woods, and that the products of the same temperature differ in elementary constitution. Exposed to moist air, the charcoals absorb more water, the lower the temperature to which they were exposed, and the inverse is true of their power of conducting heat or electricity. Charcoal made at 1500° C., conducts much better than the charcoal of gas retorts, and serves perfectly for electric illumination. The density increases in the same proportion. When lighted, charcoals remain ignited for a time, which decreases as the temperature of carbonization increases. The charcoal made at 260° C. burns more easily and longer; that made between 1000° and 1500° C. will not ignite or burn.

The most inflammable of all charcoals is that of an Agaricus. It takes fire spontaneously at 300° C. Other charcoals, prepared at the temperature 300° C., take fire in air spontaneously between 360° and 380°, according to the wood that has afforded them, the charcoals of the lighter woods burning the most readily.

When charcoals are mixed with sulphur, they inflame at a temperature much below that required when alone; the mixture of the two prepared between 150° and 400° C., is wholly consumed at 250° C. On the contrary, when the charcoal employed has been prepared at 1000° or 1500° C., only the sulphur burns.

To decompose saltpeter, the charcoals require a higher temperature; a heat of 400° C. is needed for charcoals prepared between 150° and 432°, and a red heat for those made between 1000° and 1500°.

Sulphur decomposes saltpeter at a higher temperature than charcoal requires, viz., at 432°. The sulphur alone inflames in common air at 250° C., and not at 150° as stated in treatises on chemistry.

The deflagration of powder takes place at 250°, but its combustibility varies with the charge, and the size of the grain. The powder in grains burns between 270° and 320°, while powder pulverized, burns between 265° and 270°.

In view of the facts, M. Violette concludes that it is necessary to revise the charges employed, taking into consideration the actual composition of the charcoal. Trials made with this in view upon hunting powder, with charges calculated according to the actual composition of the charcoal, have given a range much beyond the standard rate obtained with the ordinary powder.

Experiments on the Anæsthetic properties of the smoke of the Lycoperdon.—A naturalist of Paris, M. Frederic Gerard, has tried upon himself the effects of the smoke of the *Lycoperdon proteus*, (a species of puff-ball,) observed to be anæsthetic by Mr. Richardson. 12 grammes of this substance were placed on some tinder which kept up the combustion, and he placed his head in it for 15 minutes. It produced a strong irritation of the pharynx, and then of the eyes; after removing the apparatus, he experienced a series of narcotic effects, which inconvenienced him for several hours, and the next day, they had not entirely passed away.

M. Gerard has not succeeded in confirming the assertion of the "Mainzer Volkszeitung," that animals subjected to this smoke, are thrown into a state of prostration resembling death. He has found also that the properties of the *Lycoperdon bovista* and *L. excipulæformis*, are the same as those of the L. proteus.

Chloroformization.—Dr. Jobert de Lamballe, one of the principal surgeons of Paris, who has used chloroform since its anæsthetic properties were made known, has presented a long memoir on the observations which he has made on this subject, and on the precautions requisite in the employment of this stupefying liquid.

We cite some passages from his report.

Use of chloroform should cease, whenever the beatings of the heart lose at once their power and number. The physician should continually keep watch of his patient, and not judge of the action of the chloroform from his irregular movements or loquacity, for the insensibility is often produced even when there is still some agitation of the members or incoherent words; the application should be suspended whenever the pulse falls to 55; at 50 the patient may drop off from paralysis of the heart.

Recourse should not be had to chloroform when there exists any severe organic difficulty. The operation is not advisable when the nervous system has sunk from any violent shock, or when the patient is depressed by languor, abundant suppuration, loss of blood, or an advanced chlorotic state.

When chloroform has exhausted the vital forces, and death is apparent, the surgeon should never abandon the patient without trying for a long time to restore life. It is then well to excite locally the skin with cold water, or with frictions made with alcoholic solutions, alkalies, &c., to reanimate the organs by currents of air directed upon the face and members, giving the patient the position most favorable for reëstablishing the circulation, by placing him horizontally on his back, or

obliquely on one side. In one case of this kind, M. Jobert obtained good effects from the use of electricity.

This surgeon draws a parallel between chloroform and ether. Ether alters the color, and the consistence of the blood; chloroform does neither. Ether hinders often the healing of wounds, chloroform never. Chloroform calms the organs, and ether violently agitates them. Ether over-excites certain senses and certain desires, chloroform never. Ether produces death with difficulty; chloroform may cause life to cease instantaneously, if the patient is not watched, or if the respiring of the chloroform is not properly conducted. We add that quite recently two cases of death from chloroform have happened, under the eyes of physicians.

Composition of matters extracted from fertile soils by water.—In continuation of his long researches on the composition of arable soils, M. Verdeil, chief of the chemical works at the Agronomic Institute of Versailles, and M. Rissler, have recognized in the aqueous extracts of these soils, the constant presence of a substance like sugar; and also a large proportion of mineral substances, little soluble or even insoluble in water. Thus in 100 parts of aqueous extract, they found 49 of organic matter, and 54 of inorganic consisting of sulphate, carbonate and phosphate of lime, oxyd of iron, alumine, magnesia, all insoluble in water (or scarcely soluble); and as the presence of carbonic acid alone is not sufficient to explain the presence of these substances in an aqueous extract, MM. Verdeil and Rissler have sought for the cause of this solubility, and concluded that it is due to the saccharine ingredient; for only a very little water is required along with this sugar to dissolve large quantities of insoluble salts. They have recognized again the fact that nitrogen which enters into the composition of humus is found in the condition of an ammoniacal salt, and not in that of an organic substance; for they have collected the whole under the form of ammonia in boiling the concentrated extract with milk of lime.

Photography.—A discussion has taken place at the Academy, between MM. Arago, Biot and Chevreul, as to the respective rights of Mr. Talbot of London, and M. Niepce de St. Victor, as to the invention of photographic engraving on plates of steel. The processes of these chemists are different. M. Talbot uses for the substance impressible to light a mixture of gelatine and bichromate of potash, which is modified and browned on the immediate contact of light, and only where the light acts, whilst the part covered by the object to be copied remains untouched, and may always be removed by water.

M. Niepce has aimed to perfect the process which his uncle the inventor of heliography described in the year 1827. The sensitive substance is a solution of bitumen in essence of lavender, applied in a layer; this varnish changes its properties while under the action of light. The parts exposed to the sun become insoluble in a mixture of essence of lavender and oil of petroleum, so that they may be easily separated from the soluble part not impressed, which represents the image to be reproduced.

The liquid employed by Mr. Talbot for biting in on steel after his design, is bichlorid of platinum, and that of M. Niepce, a mixture made

of 1 part of nitric acid, 8 parts of distilled water and 2 of alcohol. We mention only these general facts, the details belonging more especially to the domain of technology.

Theory of the Pile and the Aurora Borealis.—M. de la Rive, the celebrated physicist of Geneva, has presented to the Academy the first volume of a treatise on Theoretical and Applied Electricity, which he has published in London, and of which he is now preparing an edition in French. In explaining the plan of his work, M. de la Rive dwelt more especially on the theory of the pile. He has always been a defender of the chemical theory ; but while acknowledging the influence of chemical action, he now recognizes that we cannot always admit that chemical action precedes the production of electricity, and he is led to consider the two phenomena as commonly simultaneous, and due to a more general cause, viz., molecular polarization, which is established at the moment of contact of two bodies susceptible of acting chemically on one another. M. de la Rive also expresses his opinion on the cause of the aurora, which he explains not by a radiation of the polar magnetism, but by a purely electrical action. After examining nearly all recent observations, he believes that he may attribute this phenomenon to the electricity with which the currents of air are charged, that rise from the equatorial regions, and travel in the upper atmosphere towards the poles, where they combine with the negative electricity of the earth, forming under the influence of the magnetic pole, true luminous arches.

Miscellaneous.—Among the various facts communicated to the Academy since my last communication, we mention the following.

The *transformation* of tartaric acid into racemic, by M. Pasteur.

A work of considerable extent *on the variations in chronometers*, by M. Lieussou, Hydrographic Engineer. The causes of these variations are now known ; they are temperature, and the gradual thickening of the lubricating oil. M. Lieussou after explaining the causes, gives the methods of remedying the evils.

A *photographic apparatus* by M. Quinet, for producing at one and the same time two images for use in the stereoscope ; it is a modification of the binocular camera obscura of Brewster.

A note of M. Gorgen, *on the coloration of salts of manganese*, tending to show, that the salts are all colored, and that if M. Voelker has obtained colorless salts, it is owing to impurities, they including certain salts, which like those of cobalt, copper, &c., are not themselves colorless, but afford the complimentary color to that of manganese, so as by mixture to generate a white color.

A letter of M. Dujardin, calling attention anew to the method of *using steam in extinguishing fires*. If one of the passengers of the steamboat Ocean Wave, had known of this property of steam, the disaster which took place on the 30th of April, on Lake Ontario, might have been avoided, or at least rendered less serious.

M. Felix Bernard has described a *new photometer*, and M. Gaugain has announced a *new electroscope* with double condensation, which increases much the sensitiveness of the electroscope of Volta.

Manufacture of Sugar.—Sugar extracted from molasses. The manufacture of beet sugar has for some years been largely carried on in France. In ten years, the production has doubled notwithstanding the

successive duties which have been laid, duties of an excessive character, since 100 kilogrammes of white loaf sugar pay 59 francs of duties, and sell at 150 francs. In 1842, the production of beet-sugar throughout France was about 40 millions kilog., and to day it is 80 millions. This progress has been owing to improvements each year in the manufacture.

Among these improvements, the most important is that called the *barytic*, introduced by MM. Leplay and Dubrunfaut, and which enables them to obtain 50 p. c. of the crystallizable sugar contained in the molasses. It is well known, that for a long time this molasses was of little value. Its sugar was supposed to be wholly uncrystallizable, and its only use was for making alcohol by fermentation, for which purpose large distilleries had been constructed. In an establishment of this kind, directed by M. Leplay, 12000 kilogrammes of the beet molasses were consumed per day, in making alcohol of 94 p. c., which was wholly used in the manufacture of fine liquors.

M. Leplay and M. Dubrunfaut, were the first to recognize that the sugar in the molasses was a sugar perfectly crystallizable, and having all the characters of ordinary sugar; and that to crystallize it, it was only necessary to separate the interfering foreign substances, by operating on the juice of the beet which furnishes the molasses. The solution of the problem was one of great importance, since the amount of molasses annually produced in France, was 40 millions kil., containing more than half its weight of sugar.

Their process, as I have studied it for some years at the establishment of La Villette, near Paris, is as follows. It is based on the insoluble compound, which sugar forms with baryta. When a boiling solution of caustic baryta at 30° Baumé, is poured into the ordinary molasses, the substances contained immediately solidify into a porous crystalline mass, insoluble in water, and admitting therefore of thorough washing.

After being thus purified, the saccharate of baryta is white, and has the appearance of a "bouillie épaisse;" it is exposed to a current of carbonic acid, which takes up the baryta and sets the sugar at liberty. This operation is carried on in large vats of wood, 80 to 100 hectoliters in size, into which strong pumps worked by steam, inject carbonic acid obtained by the calcination of carbonate of lime in lime furnaces.

While the reaction of the carbonic acid is going on, it is observed that the "bouillie" of saccharate, before very thick, gradually liquifies, and when complete, the whole is a solution of sugar containing carbonate of baryta in suspension.

To separate the carbonate, the mixture is put into sacs made of cotton fabric, through which the syrup filters clear, while the carbonate is retained. These sacs, after draining thoroughly, are pressed lightly in a screw press, and then subjected to heavy hydraulic pressure, in order to extract the syrup from the carbonate. This syrup thus obtained, marks 18 to 22° Baumé, it is white, of agreeable taste, and holds in solution some traces of the carbonate and bicarbonate of baryta which may be removed by means of a sufficient quantity of plaster, or of sulphate of alumine. Finally, it is clarified by means of dried blood; it is skimmed and filtered, and boiled down like a syrup for the re-

finery, after which it is put into forms for crystallizing. We thus obtain, at once, sugar equal in quality to the finest sugars of commerce.

With regard to the residues of this process—the carbonate of baryta, saline substances contained in the molasses, quicklime proceeding from the calcination of the limestone, etc., I have learned the following facts. The carbonate of baryta may be used an indefinite number of times; it is rendered caustic anew after each operation, by mixing it with charcoal and heating it, and so it serves again. The loss of the baryta, which is unavoidable is re-supplied from sulphuret of baryum which M. Leplay prepares by calcining sulphate of baryta with 45 p. c. of charcoal, in a reverberatory furnace, and which he would prepare more advantageously still if he would apply the process suggested by Gibbs, which consists in reducing the sulphate by the gas of the refinery. The sulphuret of baryum possesses equally the property of precipitating the sugar, only there are two equivalents of sulphur when one of oxygen would suffice. In fact, this last case gives,

$$\text{Sugar} + \text{BaO} + \text{HO} = \text{Saccharate of BaO} + \text{HO},$$

whilst the sulphuret affords,

$$\text{Sugar} + 2\text{SBa} + \text{HO} = \text{Saccharate of BaO, SH, SBa}.$$

There is hence lost 1 equivalent of sulphuret of baryum. To avoid this loss, 1 equivalent of potash or caustic soda is added to the molasses under trial; and then on pouring in the sulphuret of baryum, all the baryta is precipitated in the state of a saccharate, and the liquid retains the potassium in the state of a sulphydrate.

$2\,\text{Sugar} + 2\,\text{SBa} + \text{KO} + \text{HO} = 2\,\text{Saccharate of BaO} + \text{SH, SK}$. The use of caustic potash produces a residue with carbonic acid, like the quicklime, and would be too expensive for the purpose, were it not regenerated with each operation. In fact, the waters after washing are collected in boilers, evaporated, and the product then calcined in a reverberatory furnace with some chalk or lime, and fused. The fused substance is cooled, broken up, lixiviated, rendered caustic by means of lime, and the leyes are concentrated as in the manufacture of soda. The potash is thus obtained for a new precipitation of the saccharate.

In this operation, they obtain not only the potash added in the process, but also the potash and soda which existed primarily in the juice of the beet, and which, by accumulation in the molasses, amounts to about 10 per cent.

In this manner, MM. Leplay and Dubrunfaut have succeeded in isolating, economically, the sugar of beet molasses. But is this process applicable to the extraction of cane sugar? Yes, on one condition; that is, if the manufacture of cane sugar can be so conducted as to give molasses free from uncrystallizable sugar. For MM. Leplay and Dubrunfaut have shown that for 60 to 70 p. c. of sugar in the molasses, there are 30 p. c. of uncrystallizable sugar, which is a result of the method of manufacture, and not preëxistent in the juice of the cane.

There exists, then, great differences between the manufacture of beet-sugar and cane-sugar; in the former, the molasses contains no altered sugar, and in the latter there is a large quantity of altered sugar.

Manufacture of caustic baryta from the carbonate.—We have mentioned above the general process by means of which MM. Leplay and Dubrunfaut reduce the carbonate of baryta. The point is important

and we add some further details; for it has required much time and experiment to accomplish it conveniently on a large scale. The process is now so far perfected, that caustic baryta may be obtained at a very low price.

After reducing the carbonate to powder, it is mixed intimately with 20 to 25 p. c. of pulverized charcoal, then put in a reverberatory furnace made of good refractory brick. At a reddish white heat the reduction commences, and the aspect of the mass shows when it is complete. A single furnace will thus reduce in 24 hours 1200 kilogrammes of carbonate of baryta, consuming 12 hectoliters of charcoal in heating, and 4 hectoliters for the reduction. Three workmen are required. When finished, the baryta is collected in metal cases, ("étouffoirs," large sheet-iron boxes holding about 1 hectoliter,) where it is cooled. The artificial carbonate is usually reduced more easily than the native. However, the native carbonate from England is easily decomposed.

Caoutchouc industry.—Since Mr. Goodyear, of New Haven, Ct., has discovered the method of preserving caoutchouc elastic at all temperatures by vulcanization, this substance has become the basis of a branch of industry of the highest importance. The vulcanization of caoutchouc has been what the electro-magnet was to the electric telegraph the parallelogram to steam-engines, or tubular boilers to rapid locomotion—a discovery, great in its numerous applications, and the services which it has rendered to society.

The several branches of this industry have been undergoing constant improvement since they were first commenced. Among them we have already, in a former paper, alluded to the manufacture of caoutchouc thread.

Two processes are ordinarily used in working caoutchouc. One consists in macerating it in essence of turpentine, or naptha, till it is soft; it is then worked between cylinders till the solution resembles a soft pitch, when it is applied, usually between two pieces of cloth, so as to fit it for all the purposes of clothing, and numerous other objects.

By the other process, the cautchouc is compacted so as to form a single mass, sheet, or block, and mainly by heat and pressure. The methods are well known, and I do not dwell upon them. The processes which I would here mention, are employed by Mr. Gerard, at Grenelle, near Paris. They have the advantage of not altering the caoutchouc, and of admitting of being employed from one day to the next.

In these processes, the paste of caoutchouc acquires certain peculiar properties; it is not pasty, and will keep the form impressed upon it. Alcohol, an anti-solvent of caoutchouc, is the agent which M. Gerard used for this purpose. By causing the alcohol to penetrate the caoutchouc, the adhering molecules are disunited, as completely as when alcohol is poured into a limpid solution of caoutchouc. The solvent which is preferred for use is the sulphuret of carbon, to which is added from 2 to 25 p. c. of alcohol. To 1 part of caoutchouc, from 1 to 30 or 40 parts of the dissolving alcoholized material, according to the quality of the paste desired.

The clear solutions are applied with a brush, and dry promptly; those in a pasty state are used for making thread, tubes, leaves, etc.

The elastic material, driven by a piston through small holes, is thus made into threads; the holes are in a single range, that the threads may not fall upon one another. The threads are received on an endless band of velvet, and thus make a traverse of 4 metres; they pass then to a linen cloth or band, also without end; a sieve, shaken with an eccentric motion, sprinkles some talc over the threads, to prevent their adhesion. This movement on endless bands serves to promote the evaporation of the solvent.

The details of this process cannot be given without numerous figures, and I therefore mention only the principal steps in the manufacture. The size of the threads of caoutchouc may be varied at will. A thickness of 1 millimiter is usually preferred; but often a much finer thread is desired. M. Gerard converts the larger into smaller threads of any size desired, by means of a property which he was the first to recognize in caoutchouc—that of reheating ("recuit"). It is well known that a thread, when drawn out, will return to its former length when the force is removed. But it was not before known, that this thread when drawn out and exposed to a heat of 115° C., would retain the length and size thus given it, and, moreover, it is also ready to be drawn anew. By drawing it thus, and re-heating it, successively, a thread of caoutchouc may be brought to any degree of fineness, limited only by the skill of the workman. A length of 50,000 metres may be obtained from a kilogramme of material.

The thread thus obtained is of ordinary caoutchouc, but it is easy to make the vulcanized thread in the same manner. It is only necessary to incorporate into the pasty caoutchouc some flowers of sulphur, and heat up to 130 or 140° C. M. Gerard vulcanizes also by a process peculiar to himself, which consists in exposing the caoutchouc in an alkaline persulphuret to the action of a temperature of 150° C. This process gives good results, but the product is black.

For weaving, both kinds of thread, the vulcanized and non-vulcanized are used. Deprived of elasticity, the natural thread may be worked like any other textile material, and the elasticity may be afterwards restored, by passing a hot iron over the tissue. The vulcanized caoutchouc cannot be woven without the aid of a peculiar artifice; it must be extended by weights.

M. Gerard manufactures thus at Grenelle on an average 700,000 metres of caoutchouc thread per day. It is the only round thread used in France, the United States, England, or Germany. All other threads are square, and are obtained by cutting; they therefore have not the strength or homogeneity of the round even thread.

Locomotion by compressed air.—I close this communication by some details relative to a recent invention of considerable notoriety. The inventor, M. Julienne believes that it will prove an economical motive power of great value. What I have seen of it, satisfies me that obstacles which have till now opposed the employment of the expansive force of compressed air will disappear through the process of M. Julienne, which consists simply in compressing air by means of an hydraulic press.

By this method, M. Julienne substitutes for the *solid* piston—which a grain of sand may alter, which the slightest irregularity in the

pump would throw out of action, and which becomes heated by friction,—a liquid piston, not less incompressible than the other, filling always exactly the space in which it moves, be it regular or not, and acting by progression on a resistance so exactly calculated, that its proportion, although increasing, is always in relation to the force to be overcome.

The air is thus compressed at 30 atmospheres in iron bottles, which are about 4 millimetres thick. It is perfectly preserved under this pressure, and it was with a bottle of this kind that M. Julienne put in action, in my presence, a small vehicle, carrying two persons, and moving with great rapidity.

SCIENTIFIC INTELLIGENCE.

I. Geology.

1. *Records of the School of Mines, and of Science applied to the Arts*, Vol. 1. London, 1852. 8°.—Contains inaugural and introductory lectures to the courses for the session of 1851–2. We would notice the lecture of Prof. Ed. Forbes upon the Relations of Natural History to Geology and the Arts, as particularly interesting to the Zoologist. L. A.

2. *A Geological Map of the United States and the British Provinces of North America, with an explanatory text, geological sections, and 8 plates of the fossils which characterize the formations*; by Jules Marcou. Boston, 1853. 8°.—A comprehensive illustration of the Geology of the N. American Continent. L. A.

3. *Memoirs of the Geological Survey of the United Kingdom. Figures and descriptions illustrative of British organic remains.* Decade vi. London, 1852. 4°.—Contains descriptions of nine new species of fossil fishes from various geological formations, by Sir Philip de Malpas Grey Egerton, among which is the type of a remarkable new genus from the chalk of Sussex. It is highly gratifying to the writer to see that the fossil fishes recently discovered in Great Britain, are likely to be all described in a satisfactory manner by so competent an observer as Sir Philip Egerton, whose collection of fossil fishes, in connection with that of his noble friend, the Earl of Enniskillen, is unrivalled. L. A.

4. *Histoire des progrès de la Géologie de* 1834 *à* 1850, per A. d'Archiac. Paris, 1851. 4 vol.—This work, of which we have recently received the fourth volume, is not merely a history of the recent progress of geology, but a real encyclopedia of all the branches of science related to geology, and ought to be studied carefully by every geologist and palæontologist. L. A.

5. *Zeitschrift der deutschen geologischen Gesellschaft*, 4th vol. Berlin, 1852. 8°.—This and the preceeding volumes contain highly valuable papers upon Geology and Palæontology. L. A.

6. *Jahrbuch der kaiserlich-königlichen geologischen Reichsanstalt*, Wien, 1852. 4°.—The third volume of a very valuable series of papers upon a variety of subjects relating to Geology, Palæontology, and Mining. L. A.

7. *Geognostiche Wanderungen in Gebiete der nordöstlichen Alpen;* von CARL EHRLICH. Linz, 1852. 8°.—Geological Sketches of Upper Austria, with descriptions and figures of fossils. L. A.

8. *Die Braunkohle in der Mark Brandeburg;* von Dr. E. PLETTNER. Berlin, 1852. 8°, with a map and 4 plates.—An account of the lignites of the mark of Brandeburg, chiefly geological. L. A.

9. *Halurgische Geologie;* von Dr. F. v. ALBERTI. Stuttgardt, Tübingen, 1852. 8°.—A complete treatise of all matters pertaining to the geology of salt, its occurrence, its origin, its associations, &c., &c. L. A.

10. *Lehrbuch der Geognosie;* von Dr. C. F. NAUMANN. Vol. 2d, part 2d. Leipzig, 1852.—One more number, and this excellent textbook of Geology will be complete. What renders it particularly useful, and superior to most other works of the kind, is the beautiful atlas of characteristic fossils which accompanies it. L. A.

11. *H. G. Bronn's Lethæa Geognostica.* 3d edition published in connection with F. ROEMER. Stuttgardt, 1852. 8°.—Too well known from the former editions to require particular notice. We would only state that the new discoveries in Palæontology have been faithfully incorporated in this new edition. L. A.

12. *Deutschlands Petrefacten*, von C. G. GIEBEL. Leipzig, 1852. 1 vol. 8°.—A complete systematic catalogue of all the fossil organic remains discovered to this day in Germany and the adjacent countries, with their synonyms and the indications of the localities and geological formations in which they occur, and references to the works in which they are described. It is for Germany what *John Morris's Catalogue* is for Great Britain, and *Bronn's Index Palæontologicus* for the whole world. This last work, yet little known in this country, ought to be in the library of every geologist. L. A.

13. *Fauna der Vorwelt, mit Natur Berücksichtigung der lebenden Thiere.* Von Dr. C. G. GIEBEL. Vol. 3d. Leipzig, 1852. 8°.—This volume contains a very full description of the fossil Cephalopods known to this day. It is an indispensible work for every palæontologist. The first volume of the work is devoted to the Vertebrata. The second has not yet appeared. L. A.

14. *Zoologie et Palèontologie Françaises (Animaux vertébrés) ou nouvelles recherches sur les animaux vivans et fossiles de la France.* Par P. GERVAIS. Paris, 1852. folio. No. 15, 16, 17 and 18.—The concluding numbers of an extensive work upon the fossil remains of vertebrated animals in France. L. A.

15. *Palæontographica, Beiträge zur Naturgeschichte der Vorwelt*, von W. DUNKER and HERM. von MEYER. Vol. 2d, No. 6.—Contains the description of some remarkable fossil plants from the lithographic limestone of Solenhofen by Professor Fr. Unger. The author shows that the fossil remains referred by Count Sternberg to the family of Algæ, under the name of Caulerpites, are genuine Coniferæ, constituting a distinct genus, which he calls *Arthrotaxites.* The same No. contains interesting contributions to the tertiary flora of Silesia, by Prof. *H. R. Göppert.* Among them, we notice particularly a maple, the fruit of which measures not less than six, and sometimes over eight inches in length. L. A.

16. *Description of the remains of extinct Mammalia and Chelonia from Nebraska Territory, collected during the Geological Survey under the direction of Dr. D. D. Owen;* by Jos. LEIDY, M.D. From D. D. OWEN's Report of a Geological Survey of Western Iowa, and Minnesota, &c. Philadelphia, 1852. 4°.—This memoir affords another evidence of Dr. Leidy's indefatigable industry and devotion to the study of Natural History in all its departments. His descriptions are very full and precise; we only regret that there is nowhere yet in the country a collection of skeletons sufficiently extensive to enable our palæontologists to compare minutely the fossil remains which they describe with the bones of living animals. What interesting results might not have been derived from a careful comparison of so many fossil turtles, so well preserved as those here described and figured, with the numerous representatives of that family inhabiting even the United States. The fossil Fauna of Nebraska is one of the most important yet discovered in North America, and may furnish many more interesting extinct forms.

The mammalia described by Dr. Leidy belong to his new genera Oreodon, Archæotherium, and Eucrotaphus, and to the genera Palæotherium, Rhinoceros, and Machairodus, he and Dr. Owen have added new species, all of which are beautifully illustrated. The reptiles, four in number, belong all to the genus Testudo proper. Besides the species described in full, there is at the close of this paper a list of five other species mentioned elsewhere before. L. A.

17. *Memoir of the extinct species of American Ox;* by Jos. LEIDY, M.D. From the Smithsonian Contributions to Knowledge. Vol. v.—This is a very valuable contribution to the natural history of the fossil species of Ox found in North America. The author refers them to two genera: 1st, *Bison*, the type of which is our Buffalo, and, 2d, a new extinct genus, which he calls *Bootherium*, which contains two distinct species. The validity of these distinctions seems satisfactorily established; it is also very interesting to learn that remains of the common buffalo are found among the fossils of Big-bone Lick, in Kentucky. But we cannot help repeating our regrets, that such important investigations should be carried on without the possibility of direct comparisons with the skeleton of our living species. It is a strange fact, that there is no skeleton of the Buffalo in any American museum, except that of the Natural History Society in Boston. It remains, therefore, for future investigations to ascertain what is the degree of affinity of the fossil American Bulls with the living species of this continent. L. A.

18. *Die Versteinerüngen der Grauwacken formation in Sachsen ünd den angrenzenden Länder-abtheilungen*, von H. B. GEINITZ. No. 1, Graptolites. Leipzig, 1852. 4°.—No family of fossils has puzzled the palæontologists in a higher degree than the Graptolites, especially when it has been attempted to assign them a place among organized beings. The nearest approach to a natural classification has been proposed by Barrande and Geinitz, who compare them to those Halcyonoid and Hydroid Polypi, in which the individual animals are arranged in regular rows, such as Virgularia and Sertularia. I believe, however, that their true position is neither among Polyps, nor among Acalephæ, to which class the Hydroid polyps must now be referred, but among Molluscs, in the class of Acephala, in the order of Bryozoa, of which many are found

in a fossil state in the palæozoic rocks. My reason for assigning such a position to the Graptolites, is the discovery I have made in Florida upon the coral banks of Key-West, of a new genus of Bryozoa, in which the arrangement of the cells resembles that of the Graptolites still more than either Virgularia and Sertularia, and the delicate stem of which, if fossilized, would probably have left an impression very similar to that of most Graptolites. I have not yet had an opportunity of publishing my investigations upon this singular creature; but I have no doubt left in my mind that it is a living representative of the fossil Graptolites, for which I propose the name of Cladobryus hyalinus, as it differs from most of the ordinary Bryozoa, by the regular branching of its stem, and resembles, in that respect strikingly, the new genus Cladograpsus of Geinitz. I have collected a sufficient supply of this remarkable animal, in alcohol, to provide all the palæontologists with it. To trace the true affinities of the Graptolites, the genera Crisia, and Eucratea, ought to be compared. Upon this interesting subject, compare, also, J. Hall's Palæontology of New York, vol. i and ii.

L. A.

19. *Beitrag zur fossilen Flora von Wildshuth in Oberoestreich*, von Dr. C. von Ettinghausen, with 4 plates. From the Proceedings of the Imperial Academy of Sciences at Vienna, vol. ix, 1852.—Descriptions and Figures of many fossil plants from the lignites of Wildshuth, in Upper Austria. L. A.

20. *Neu aüfgefundene Saurier-Ueberreste aus den lithographischen Schiefern des obern Jurakalkes*, von Dr. Andreas Wagner. München, 1852. 4°. From the Transactions of the Royal Academy of Sciences of Bavaria, vol. iii.—Contains full descriptions and accurate figures of two new genera of fossil Saurians, Pliocormus, and Homœosaurus, and new contributions to the knowledge of several Pterodactyls, with new species of Pliosaurus, Ichthyosauras, and Stenosaurus.

L. A.

21. *Description des Mollusques fossiles qui se trouvent dans les grès verts des environs de Genève*, par F. J. Pictet. Genève, 1852. 4°. 3d number.—The third number of an elaborate monograph of the cretaceous fossils of the vicinity of Geneva, in Switzerland, with many beautiful plates. A work indispensible for the identification of our greensand fossils. L. A.

22. *Die Kreidebildungen von Texas und ihre organischen Einschlüsse*, von Dr. Ferd. Roemer. 4°. Bonn, 1852.—A very handsome volume, giving an account of a geological survey of Texas, and the description of the fossil remains found in the cretaceous and tertiary formations of that state, with eleven magnificent plates. L. A.

23. *Système silurien du centre de la Russie par Joachim Barrande.* 4°. 1852. 1 vol. letter-press, 935 pages: 1 vol. plates, 52 in number. —This work, advertised for many years, has at last made its appearance in a shape that exceeds the most sanguine expectations. It is natural to have to wait for such productions. The first volume now before us contains only a monograph of the Trilobites; but they are illustrated as fully and minutely as if the dissections had been made from specimens just caught upon some mud-flat left dry by the ebb tide, and the changes some of them undergo with age are treated as extensively

as if they had been hatched in confinement, and brought up in a nursery. Zoologists may well be called upon to imitate the example modern palæontologists give them; living animals ought, indeed, to be so minutely described as to furnish ready means of comparison in the identification of fossils, whilst of late the most important contributions to Natural History have been made by palæontologists. Science has another master worker in its service, for we may almost consider this book as the first work of Mr. Barrande. L. A.

[NOTE.—In § 13, p. 280, for *Natur* read *steter*.]

24. *Fossil Saurian Bone from Prince Edward's Island.*—Mr. J. W. Dawson describes briefly in the "Eastern Chronicle" of Nova Scotia, for June 28, 1853, a fossil bone found in sandstone, at New London, on Prince Edward's Island. The specimen is a fragment of a jaw-bone, about 7 inches long and 5 broad. It contains 8 conical teeth of various sizes, set in true sockets, the largest being an inch and a quarter in length above the surface of the jaw, and having about a fourth of an inch broken off at the summit; they are all flattened laterally, and slightly curved backwards, and are finely serrated on the edges. The teeth and bone are white, and in excellent preservation, and they are attached to the original matrix of soft red sandstone. It was found 21 feet from the surface. The rock is believed to correspond in geological age with the trias or new red sandstone.

25. *New South Wales.*—Various reports of explorations in the gold region of New South Wales, by the Rev. B. W. CLARKE, have been received by us. They are confined to local details, and afford little that we can extract to advantage. The explorations were mainly along the Australian Alps, where the rocks are granite, and various slates, the latter often much contorted. The region is in many parts much intersected by trap dykes. We hope to receive a general review of the subject from the author who is indefatigable in his explorations.

II. ZOOLOGY.

1. *Neue Denkschriften der allgemeinen Schweizischen Gesellschaft für die gesammten Naturwissenschaften.* Zurich, 1850. Vol. xi.—Though published three years ago we notice this volume now, in order to refer to two important papers contained in it; one by Prof. O. Heer, upon the fossil insects of Oeningen and Radeboy, the other by L. Rütimeyer upon the nummulitic formation of Switzerland, with a detailed description of the nummulites of that geological period. L. A.

2. *Memorias dela real Academia de Ciencias de Madrid.* Madrid, 1851. Vol. i, part 1 and 2.—Contains several valuable papers upon the Geology and Zoology of Spain. L. A.

3. *Catalogue of the Cabinet of Natural History of the State of New York.* Albany, 1843. 8°.—The Regents of the University deserve great credit for directing the publication of this catalogue. Nothing is better adapted to secure permanently the interest for public collections, and to contribute to their increase than the circulation of such catalogues. We only regret that no more direct reference is made to the individual specimens described and figured in the Natural History of New York. The importance of preserving such records to favor the researches in

case of doubts, upon the identity of a newly discovered species, cannot be overrated, and we would particularly call the attention of all the directors of Museums to this point. The chief value of many of the museums of Europe arises from the circumstance that they contain the original specimens described by the naturalists who have brought our science to its present condition. In this respect, we cannot commend too highly the catalogues of birds and eggs, published by the Academy of Nat. Sciences, of Philadelphia, drawn up by John Cassin and A. L. Heerman, Esq. L. A.

4. *Bulletin de la Société impériale des Naturalistes de Moscow, publié sous la redaction du Dr. Renard.* Moscow, 1852. 8°.—This periodical contains papers upon almost every department of Natural History. L. A.

5. *Jahresbericht des naturwissenschaftlichen Vereins in Halle.* Berlin, 1852. 8°—Touches upon a variety of topics in various departments of Nat. Hist. L. A.

6. *Sitzungsberichte der Kaiserlichen Academie der Wissenschaften.* Wien, 1852. 8°.—Like the proceedings of other academies, contains short abstracts of the papers presented to the imperial Academy of Science, in Vienna, embracing the whole scope of human knowledge. L. A.

7. *Wurtembergische naturhistorische Jahreshefte.* 9th vol, Stuttgardt, 1853. 8°. Conducted by Prof. H. v. Mohl, Pr. Flieninger, Pr. Fehling, Dr. W. Menzel, and Pr. Krauss in Stuttgardt.—This and the preceding volumes contain very valuable papers upon Zoology, comparative Anatomy, Palæontology and Botany. L. A.

8. *Zeitschrift für wissenschaftliche Zoologie, herausgegeben von Prof. C. Th. v. Siebold ü. Alb. Kölliker.* 4th vol. Leipzig, 1853. 8°.—The most important recent Journal of comparative Zoology and Anatomy; contains numerous illustrations. L. A.

9. *De l'homme et des races humaines*, par H. Hollard. Paris, 1853. 1 vol. 12°.—A work intended to prove the origin of all mankind from a single pair, and also to illustrate the varieties of men as derived in the course of time from a common stock. These views may satisfy those who seek merely for arguments in favor of an opinion generally received, without taking into consideration the range of facts in nature bearing upon this important subject. L. A.

10. *Die Geographische Verbreitung der Thiere*, von L. K. Schmarda. Wien, 1853. 8°. 3 parts.—The first comprehensive treatise on the geographical distribution of animals, including all classes of the animal kingdom. L. A.

11. *Histoire Naturelle des Mollusques Ptéropodes*, par MM. Rang and Souleyet. Paris, 1852. 1 vol. fol.—A beautiful monograph of all the Pteropodous Molluscs known to this day, with 15 magnificent plates. L. A.

12. *Bilder aüs dem Thierleben*, von Carl Vogt. Frankfurt, 1852. 8°.—A very clever book, giving a most interesting account of investigations made upon Salpa during a residence at Nizza. Also an elaborate treatise upon the growth and formation of animals and the succession of fossils in former geological periods. This, and the other works of the author, show him to be thoroughly acquainted with the questions

now under discussion among naturalists; but we shrink with disgust from his cynicism and atheistic philosophy. L. A.

13. *Entwicklungsgeschichte des Meerschweinchens*, von Dr. Th. L. W. Bischoff. Giessen, 1852. 4°.—Another of those masterly monographs which have placed Prof. Bischoff at the head of the embryologists of our day. Nothing would contribute more efficiently to promote similar investigations in this country, than the publication of translations of his works, which the Smithsonian Institution might well undertake, for the benefit of American Naturalists. We would recommend that most of the earlier embryological works be equally translated, for no one ought to proceed in these investigations without consulting the works of Pander, Baer, Rathke, &c., &c., which are hardly to be seen in any American library, though they constitute now the basis upon which modern physiology has been renovated. L. A.

14. *Naturwissenschaftliche Reise nach Mossambique*, von W. C. H. Peters. Part 1, Mammalia, 200 pages, 4°, with 46 plates. Berlin, 1852.—In the year 1842, the King of Prussia granted to Dr. Peters the means of undertaking a scientific expedition into regions of Africa heretofore entirely unexplored by naturalists, the coast and interior of Mossambique. The volume before us contains a description of the mammalia observed during the residence of Dr. Peters in that inhospitable region. It is a full illustration of the subject, giving not only descriptions of the external appearance of the animals mentioned, but also descriptions and illustrations of the skeleton, the teeth, and sometimes even of the other organic systems. Nothing could be more welcome to zoologists than such an account of the animals of that region, so particularly interesting from its position, opposite to Madagascar, and the uncertainty which has prevailed up to this day respecting the resemblance of its inhabitants, and those of that large Island. Whether the peculiar forms of animals known to inhabit Madagascar, such as the Makis, were also to be found upon the opposite coast of Africa, or not, was a question no body could answer before the invaluable researches of Dr. Peters furnished us with the necessary data to contrast the two faunæ. Mossambique is now known to have a genuine African fauna. Its monkeys, six in number, belong to the genera Cercopithecus, and Cynocephalus. No genuine *Makis* have been observed, and only one species of Otolicnus, a genus which has also its representative in Western Africa. This is the more interesting since Dr. Peters observed two Makis alive from Anjoana, one of the Comoro Islands. The minuteness of the descriptions of Chiroptera and Insectivora deserves particular notice, for many of the species of these families enumerated in our systems cannot be recognized from want of sufficient accuracy in the details given of their characteristics. He enumerates not less than eighteen species of Chiroptera, belonging to the genera Pteropus, Cynonycteris, Epomophorus, Phyllorhina, Rhinolophus, Nycteris, Emballonura, Taphozoas, Dysopes, Vespertilio, Nycticejus, among which there are several belonging exclusively to the continent of Africa. Of Insectivora the number is nine, belonging to the truly African genera Chrysochloris and Macroscelis, to the cosmopolite genus Sorex, and to two genera, Petrodromus and Rhyncocyon, first described by Dr. Peters himself, from Mossambique. How truly African this country is,

appears, perhaps, still more distinctly from its carnivorous animals, among which we notice the lion, the leopard, the spotted hyena, several ichneumons, &c., altogether nineteen species, some of which are new, belonging to the genera Herpestes and Bdeogale. One species of Viverra, the Rasse of Horsfield, observed upon Anjoan, furnishes another evidence that even the small islands east of the African continent partake more of the Zoological character of the East Indies and Madagascar, than of Africa itself. Of gnawing animals, twenty-three species were observed, belonging to the genera Sciurus, Myoxus, Meriones, Mus, Acomys, Cricetomys, Hystrix, and Lepus, and to four new genera, Heliophobius, Pelomys, Steatomys, and Saccostomus. It is interesting to notice among these many Glires a new southern species of the truly African genus Hystrix. Most of these animals are handsomely illustrated, and their skulls and dental system represented with all the required minuteness. The Edentata number a single species of Manis, identical with that of the Cape of Good Hope. The only wild horse, Equus zebra, has long been known from other parts of the continent. How numerous the elephants must be, can readily be estimated from the statement of Dr. Peters, that about ten thousand of these animals are annually killed for their ivory. The most common rhinoceros is the same as that of the cape, first described by Camper as Rh. africanus, Cuvier's Rh. bicornis; another species is Rh. Simus. The Hippopotamus is very common in all the fresh waters of Mossambique. Besides these Pachyderms, one species of Phacochœrus, and one of Hyrax are noticed. Among ruminants, the giraffe is wanting, nor are even domesticated camels ever seen in Mossambique, but the antelopes occur very extensively, and several new species are described. Domesticated goats, sheep, and cattle have been introduced from the Comoro Islands and from Madagascar. Some varieties of sheep have been imported from the East Indies and even from America. The wild bull of Mossambique is Bos caffer, a species formerly found as far south as the Cape. Of Cetacea, the Dugong, Halicore indicus, inhabits almost the whole eastern coast of Africa. The sperm whale, Physeter macrocephalus, is said to have been very common in the Canal of Mossambique; it is now rare there, as are also other Cetacea.

It is to be hoped that the next volumes of this Fauna of the Oriental coast of Africa will soon follow the first. We may look forward to a great zoological treat, in becoming acquainted with the fishes of the Zambese. Such works furnish invaluable contributions not only to special zoology, but also to the geography of animals, and are equally creditable to their authors and to the governments patronizing such costly publications. L. A.

15. *On the Osteology of the Head of Hippopotamus, and a description of the Osteological characters of a new genus of Hippopotamidæ*; by Jos. Leidy, M.D. From the Journal of the Acad. of Nat. Science of Philadelphia. N. S., vol. 2, p. 3.—In this interesting paper Dr. Leidy shows that the Hippopotamus of Senegal, and that of the Cape of Good Hope, first considered as distinct species by Desmoulins and Duvernoy, differ truly specifically, and that the third species described by Dr. Morton as Hippopotamus liberiensis is not only specifically distinct, but constitutes a distinct genus, for which the name Chœropsis is proposed.

L. A.

16. *Museum Heineanum: Verzeichniss der ornithologischen Sammlung des Oberamtmann Ferd. Heine*, von Dr. JEAN CABANIS. Halberstadt, 1850–51. 8°.—Invaluable as far as a correct synonymy is of importance in the study of Natural History. The author objects justly and energetically to the practice now prevailing of separating the specific from the generic name in the quotations of authorities. Upon this point see also the introduction to my Nomenclator Zoologicus. L. A.

17. *Journal für Ornithologie*, von Dr. JEAN CABANIS. 1853. 8°.—The first number of a Journal devoted exclusively to Ornithology, published with the coöperation of the most prominent ornithologists of Europe, by Dr. Cabanis, keeper of the Zoological Museum in Berlin. L. A.

18. *Analecta ad Entomographiam provinciarum occidentali meridionalium imperii rossici;* auctore S. B. GORSKI. Fasc. 1. Berolini, 1852. 8°.—A monograph of the Neuropterous Insects, and the description of some new species of Hymenoptera of south eastern Russia. L. A.

19. *Monographia Pneumonopomorum viventium;* auctore L. PFEIFFER. Casselis, 1852. 8°. 1 vol.—A complete monograph of the pulmonate Gasteropods, provided with an operculum. L. A.

20. *Illustrations of the Birds of California, Texas, Oregon, British and Russian America:* intended to contain descriptions and figures of all North American birds, not given by former authors, and a general synopsis of North Amerian ornithology. To be completed in 30 parts each part to contain 5 colored plates; by JOHN CASSIN. 8vo. Philadelphia, 1853. Lippincott, Grambo & Co.—A very handsome number, with beautiful plates. The synopsis of Parinæ is given as a specimen of the manner in which the species not described will be mentioned; and it includes also descriptions and figures of the species *Cyanocorax luxuosus*, or Mexican Jay, the *Melanerpes formicivorus*, or Californian Woodpecker, the *Lophophanes atricristatus*, or Black-crested Chickadee, the *Cyrtonyx Massena*, or Massena Partridge, *Larus Heermanni*, or White-headed Gull. The work is highly important, and will add a new value to those published before, by other writers, upon the natural history of birds of North America. If completed in the style begun, it will be a most valuable addition to the natural history of the United States. L. A.

Subscriptions to the work are solicited by the publishers.

21. *Versuch einer Monographie der Lycænen, als Beitrag zür Schmetterlingskunde mit Abbildungen nach der Natur*, von BERNHARD GERHARD. Hamburg, 1853. 4°. Nos. 9 and 10.—The concluding numbers of a monograph of one of the most variable and difficult groups of Lepidoptera. L. A.

22. *Notes on the Classification of the Carabidæ of the United States;* by Dr. JOHN L. LE CONTE. From the transactions of the American Phil. Society. Vol. x. 1853.—We regret not finding time for the present to read and review the many special entomological papers Dr. Le Conte has published recently; but we cannot pass entirely unnoticed one upon the classification of the Carabidæ, which contains a thorough discussion upon the most prominent features of this difficult family, and the natural limitation of its subdivision and the characteristics of its genera, with a complete revision of the North American species. L. A.

III. Astronomy.

1. *Shooting Stars of August* 10, 1853.—The observations here recorded were made at New Haven, Conn., by Messrs. Francis Bradley and Lyman Baird, with myself, on the night of Wednesday, August 10, 1853. We were stationed together, in the open air, each observer having in his view, as far as practicable, a third part of the visible heavens. The time was highly favorable, the air being clear and calm, and the moon absent. Systematic observations were commenced at midnight, and continued until 3h. 25m. A. M. of the 11th, and the following table shows the number of different shooting stars seen by us during this period:

		S.	N. N. W.	E. N. E.	TOTAL.
0^h to 1^h	A. M.	48	27	35	110
1 " 2	"	42	34	39	115
2 " 3	"	57	31	31	119
3 " $3\ 25^m$	"	26	7	11	44
					388

Besides the meteors above enumerated, we saw about twenty during the quarter of an hour preceding midnight, rejected fifteen or twenty doubtful cases, and lost some after three o'clock on account of advancing daylight, and other causes. No meteor was twice reckoned, although many were of course seen in common by two observers.

Of these meteors the large majority, probably not less than three-fourths, moved in paths which traced back would intersect very near the cluster in the sword-handle of Perseus, and during our observations this apparent radiant place did not change its position among the stars. Many of the meteors left trains behind them, and exceeded in brilliancy stars of the first magnitude, while a few equalled in splendor the planet Venus.

It is evident from the foregoing statements that the periodical meteoric display of August 9–10th has appeared this year in usual form, and in numbers not much diminished. In order to render the numbers above given comparable with those of former years when four observers were on the watch, about one-sixth should probably be added thereto.

It may be worthy of mention, that slight manifestations of the *Aurora Borealis* were visible about 2 A. M. of the 11th, for about fifteen minutes, and again about 3 A. M., the light being in each case an irregular patch, extending from two to five degrees above the horizon, and wholly on the west of the north point.

As early as 2h. 15m. A. M. it was certain that there was some unusual though faint illumination along the northeastern horizon. As the morning advanced this illumination became brighter, and was recognized as the *Zodiacal Light;* but it was impossible to describe its outline, or to decide on the place of its termination. It extended from the N. E. horizon, covering the stars *Castor* and *Pollux*, stretching upwards and onwards to the vicinity of θ *Aurigæ* and β *Tauri*, while no trace of the light could be discerned south of the ecliptic. The sky in this quarter seemed to be somewhat hazy.

During the night of Tuesday, the 9th inst., the sky was too cloudy for observation.

E. C. Herrick.

2. The planet discovered on the 5th of April, by Professor Gasparis, has been named Themis, with the sign (24).

3. *Phocea*, (25) (Compt. Rend. xxxvi, 991.)—The following elliptic elements of this planet have been communicated by M. Valz :—

Epoch, 1853, May 1·486.

Mean anomaly,	305° 17′
Long. of peribelion,	303 14
" asc. node,	214 0
Inclination,	21 24
Excentricity,	0·24441
Semi-axis maj.,	2·3762
Mean daily motion,	968″·70

4. The planet discovered on the 5th of May last, by Mr. Luther, has been named *Proserpine;* its sign is (26).—*Compt. Rend.*, xxxvi, 1015.

5. Third Comet of 1853, (Astron. Journ.)—*Mr. Klinkerfues*, assistant at the Göttingen Observatory, detected a small comet on the 10th of June. At 13ʰ 0ᵐ 54ˢ, its position was R. A. 143° and N. Decl. 43°·5. It had a tail 3′ or 4′ in length. The following elements are given by *Bruhns* :—

Perihelion passage,	Aug. 27·213	M. T. Berlin.
Long. perihelion,		310° 31′ 12″·1
Place of asc. node,		140 50 27 ·6
Inclination,		59 54 23 ·1
Log. perihelion dist.,		9·491256

Motion direct.

IV. Miscellaneous Intelligence.

1. *American Association for the Advancement of Science.*—The seventh meeting of the American Association was held at Cleveland, during the week following the 28th of July. Prof. B. Peirce, of Cambridge, was President for the year. The meeting was less well attended than those of former years, owing partly to the engagements of many of the members of the Association at the different institutions of the country, with which they are connected. Among the papers presented, those of the departments of Physics and Mathematics were much the most numerous, and were mostly of high merit. There were but few papers brought forward in Geology, or Chemistry. The meeting adjourned on Tuesday, the 2d of August, to meet in Washington, on the last Wednesday of April, 1854.

A committee for revising the constitution of the Association was appointed, consisting of Prof. Bache, Dr. J. Lawrence Smith, Dr. Le Conte, of Georgia, Dr. W. Gibbs, of New York, Dr. B. A. Gould, Jr., Prof. W. B. Rogers, Prof. J. D. Dana, Dr. J. Leidy, Prof. S. S. Haldeman, and Dr. A. A. Gould. Resolutions were passed reducing the annual assessment from $3 to $1, and requiring that the Proceedings should be furnished to members at cost, or free of expense when the Proceedings are published by the public liberality of the city where the meeting may be held.

The following officers were appointed for the ensuing year: Prof. J. D. DANA, President; Prof. J. LOVERING, of Cambridge, General Secretary; Prof. J. LAWRENCE SMITH, Permanent Secretary, and Dr. ELWYN, Treasurer.

Dr. B. A. Gould, Jr., was requested to prepare an obituary of the late Sears C. Walker, to be presented at the meeting at Washington.

The following is a list of the papers read at the Cleveland meeting. We deem it the only just course to authors not to publish abstracts of their papers, unless such abstracts are made out by themselves, and sent to us expressly for publication.

(1.) *Physics, Mathematics, Astronomy.*

Prof. B. PEIRCE, of Cambridge, Mass.: Investigations in Analytical Morphology: No. 1, Description of the Science; 2, Stable and Unstable forms of Equilibrium; 3, forms of the Elastic Sac; 4, Stability of Saturn's Ring.

——— Personal Scale of Astronomical Observers.

——— Criterion for the rejection of doubtful observations.

——— Theory of the action of Neptune upon Saturn.

Prof. A. D. BACHE, Supt. Coast Survey, Washington: On the Tides at Key West, Florida, from observations made in connection with the U. S. Coast Survey.

——— On the Tides of the Western Coast of the United States, from Observations at San Francisco, California, in connection with the U. S. Coast Survey.

Prof. STEPHEN ALEXANDER, of Princeton: On some special analogies of Structure in the Eastern Hemisphere of the Earth and the visible Hemisphere of the Moon, with conjectures as to the Structure and Appearance of those portions of the Moon which are invisible.

——— On some Relations of the Central Distances of the Primary Planets, Satellites, and Rings of the Solar System, of which Bode's Law would seem to be but an imperfect expression.

——— On the Primitive Form and Dimensions of the Asteroid Planet, the cause of the Instability of the same, and of the Varieties in the Orbits of the Asteroids.

Prof. W. CHAUVENET, of the U. S. Naval Academy: On the Method of finding the error of a Chronometer by equal altitudes of the sun.

——— New Formulas of Spherical Trigonometry.

Dr. B. A. GOULD, Jr., of Cambridge, Mass.: On Personal Equations in Astronomical Observation.

——— On the Velocity of Transmission of Electric Signals along Iron Telegraph Wires.

——— On the comparative precision of the Electro-chronographic or American Method of Observation.

Prof. O. M. MITCHEL,: On a New Method of securing Uniform Circular Motion in the Machinery used in receiving the Registration of Astronomical Observations of Right Ascension.

Prof. C. W. HACKLEY, of New York: Mathematical Analysis of the contact of surfaces in oscillating Machinery.

Lt. E. B HUNT: On Cohesion of Fluids, Evaporation, and Steam Boiler Explosions.

——— The Conical Condenser, a Telescopic Appendage.

Prof. JOHN H. C. COFFIN, of the Washington Observatory: Some errors peculiar to the observer, which may affect determinations of the declinations of the Fixed Stars.

Dr. JULIUS FRIEDLÄNDER, of Berlin: On the limit toward which the series,

$$1+\frac{1}{2^{1+p}}+\frac{1}{3^{1+p}}+\frac{1}{4^{1+p}}+\text{ &c.,}$$

converges for $p=0$.

Prof. O. N. STODDARD, of Miami University: Strictures on the mechanical explanation of the zig-zag path of the Electric Spark.

Prof. J. L. RIDDELL, of New Orleans: Theory of Molecular Forces, explanatory of the gaseous, liquid, and solid conditions of matter.

Prof. JOSEPH HENRY, of Washington: Illustrations of Cohesion.

Prof. JOSEPH LOVERING, Cambridge: On a Modification of Soleil's Polarizing Apparatus for Projection.

——— On a singular case of internal Fringes, produced by interference in the eye itself.

Prof. GEO. R. PERKINS: Description of a plan for furnishing a Fluid Mirror, to be used in a Reflecting Telescope.

D. VAUGHAN, of Cincinnati: The Zodiacal Light, the periodical appearance of Meteors, and the point in space to which the motion in the Solar system is directed.

(2.) *Meteorology.*

W. C. REDFIELD: On the value of the Barometer in navigating the American Lakes.

Prof. E. LOOMIS, of New York: Does the Moon exert a sensible influence upon the Clouds?

——— Notice of a Hail Storm, which passed over New York, July 1, 1853.

J. H. COFFIN, of Easton, Pa.: An Investigation of the Storm Curve, deduced from the Relations existing between the direction of the Wind, and the Rise and Fall of the Barometer.

LORIN BLODGET, of Washington: On the Barometric Pressure in extreme Latitudes, and the existence of Belts of low Barometer in the Arctic Regions.

——— On the South East Monsoon of Texas, the Northers of Texas and the Gulf of Mexico, and the abnormal Atmospheric Movements of the North American Continent generally.

——— On the distribution of Heat over the North American Continent, and the construction of its Isothermal Lines.

——— On the Subordination of Atmospheric Phenomena, or the Position of the several Classes with respect to the primary Cause or Initiatory Processes.

——— On the distribution of precipitation in Rain and Snow on the North American Continent.

Prof. A. D. BACHE, Supt. U. S. Coast Survey, Washington: On the Winds of the Coast of the United States on the Gulf of Mexico.

Prof. JOSEPH LOVERING, Cambridge: On optical Meteorology.

(3.) *Geology, Geography, Chemistry.*

Prof. J. M. SAFFORD, of Lebanon, Tenn.: On the parallelism of the lower Silurian groups of Middle Tennessee with those of New York.

W. C. REDFIELD, of New York: On the Geological Age and Affinities of the Fossil Fishes which belong to the sandstone formations of Connecticut, New Jersey, and the coal field near Richmond, in Virginia.

A. WINCHELL, of Eutaw, Alabama: On the Geology of the Choctaw Bluff.

Dr. J. A. WARDER, of Cincinnati: A Geological Reconnoisance of the Arkansas River.

J. S. NEWBERRY, M.D., of Cleveland: On the Structure and Affinities of certain Fossil Plants of the carboniferous era.

——— On the Carboniferous Flora of Ohio, with descriptions of fifty new Species of Fossil Plants.

——— On the Fossil Fishes of the Cliff Limestone of Ohio.

Prof. J. BRAINERD, of Cleveland: Origin of Quartz Pebbles in the Sandstone Conglomerate, and the Formation of the Silicious Stratified Rocks.

L. F. POURTALES, Ass't in Coast Survey. Presented by Prof. BACHE, Superintendent: Notes on the Specimens of the bottom of the Ocean, brought up in recent explorations of the Gulf Stream, in connection with the Coast Survey.

Prof. BACHE, Supt.: Recent Discovery of a Deep-sea Bank on the eastern side of the Gulf Stream, off the Coast of South Carolina, Georgia and Florida, by Lieuts. Commanding Craven and Maffit, U. S. N., Asst's Coast Survey.

Dr. F. A. GENTH and Dr. W. GIBBS: On a remarkable class of conjunct bases containing Cobalt and the Elements of Ammonia.

Prof. E. N. HORSFORD: On the Solidification of the Coral reefs of Florida and the source of Carbonate of lime in the growth of corals.

(4.) *Zoology and Botany.*

Dr. W. I. Burnett, of Boston: On the Blood Corpuscle—holding Cells, and their relation to the Spleen.

——— On the Formation and Mode of Development of the Renal Organs in Vertebrata.

——— On the Formation and Functions of the Allantois.

——— Researches on the Development of the Viviparous Aphides.

——— On the Reproduction of the Toad and Frog, without the intermediate stage of Tadpole.

——— On the Signification of Cell Segmentation.

Prof. J. Riddell, New Orleans: On the Histology of Red Blood.

——— On the Origin of Capillary Blood Vessels.

——— On the Structure and Transformation of Oscillaria aureliana.

S. N. Sanford, of Granville, Ohio: On some points in the History of Gordius.

R. Howell, of Nichols, New York: On the Wheat Fly, and its Ravages.

Prof. Alphonso Wood, of Cincinnati: On Six New Species of Plants.

(5.) *Miscellaneous.*

Prof. E. Loomis, of New York: On the Measurement of Heights by the Barometer.

Prof. John Brocklesby, of Trinity College, Hartford: On the Rising of Water in Springs immediately before Rain.

W. H. B. Thomas, of Cincinnati: Indications of Weather, as shown by Animals and Plants.

Prof. E. N. Horsford, of Cambridge, Mass.: On the fatal effects of Chloroform.

Prof. S. S. Haldeman, of Columbia, Pa.: Investigation of the power of the Greek Z, by means of Phonetic Laws.

Loren Blodgett, of Washington: On the Earthquake of April 29, 1852.

Lt. E. B. Hunt: Remarks on Lithography and Lithographic Transfers.

——— Project of a Geographical Department of the Library of Congress.

Prof. J. L. Riddell, New Orleans: On the Binocular Microscope.

Capt. Wilkes: Account of Experiments on Sound.

——— Notice of Bradford's Machine for separating metals by their specific gravity.

Andrew Brown, of Natchez, Miss.: On the effect of the Reclamation of the annually inundated Lands of the Mississippi Valley upon the general Health of the country, and the navigation of that River.

Rev. P. R. Lynch, of Charleston: The Artesian Well, Charleston.

Herman Haupt, Supt. of the Pennsylvania Central Railroad, Philad.: On the Resistance of the Vertical Plates of Tubular Bridges.

2. *Note, by Prof.* Barnard, *to p.* 224, *on the effect of Moisture on the Heat developed by Compression of Air.*—In making this computation, no account is taken of the hygrometric state of the air; because, according to the tables of Gay Lussac and Regnault, the ordinary tension of the vapor present in the atmosphere is only $\frac{1}{110}$ of the total elasticity, or less than ·3 of an inch of mercury. This vapor cannot affect the power of the engine one way or the other; since its coefficient of expansion by heat is the same as that of air. If it existed in a more appreciable quantity, however, it would increase the consumption of heat without increasing the labor performed; for the twofold reason that the specific heat of watery vapor (by weight or by *volume*) exceeds that of air, (*Regnault, Comptes Rendus*, Apr. 18, 1853,) and the γ, for vapor, according to Dulong, is as high as 1·5, (*Péclet, Traité Elementaire de Physique.*)

3. *Note, by Prof.* Barnard, *to p.* 225, *on the Heat required to convert Water into Steam.*—The (so-called) *latent* heat of steam, has been very differently stated by different experimenters. Poisson (*Traité de Me-*

canique) puts it at 550° C., adopting the determination of Désormes and Clement as a mean. As 560° C. =990° F., we have

$$990°+212°-60°=1142°,$$

for the qnantity of heat necessary to convert water at 60° into steam at 212°.

4. *Note to p.* 226, *on the Theoretic Determination of the Expenditure of Heat*; by Prof. BARNARD.—A partial compensation for this expenditure, arising from expansion after cut-off, overlooked in the text, seems to be of sufficient importance to deserve attention in this postscript note. When the supply cylinder is less than the working cylinder, the density of the heated air is, at the end of the stroke, necessarily, in the same ratio, less than unity. In this case, it is $\frac{2}{3}$. Now this air cannot be discharged at a less pressure than that of the atmosphere; and, in the general formula,

$$p'=p\left(1+\frac{\theta}{519}\right)\varrho,$$

If we put $p'=p$, and $\varrho=\frac{2}{3}$, $1+\frac{\theta}{519}$ must be equal to $\frac{3}{2}$; or $\frac{\theta}{519}$ to $\frac{1}{2}$. That is, θ must be 259°·5 above the initial temperature, (60° F.) or 289°·5 above 32° F.

The temperature in the working cylinder, after expansion, is 322°·2. As the air passes the regenerator (supposing this contrivance to absorb all the sensible heat above that which is due to compression =116°·54) its density will remain unchanged while it cools from 322°·2 to 287°·5. But from 287°·5 to 116°·54, the atmospheric resistance increases the density; and the cooling takes place as *under constant pressure*. Through 170°·96, therefore, (=287°·5−116°·54) the air imparts to the regenerator the calorific equivalent of K_p and not of K_v for every degree of cooling and every unit of mass.

Now 170°·96×·36=61°·5456, which should be deducted from the apparent consumption, as given in the text; leaving the actual theoretic consumption, an amount representable in mechanical equivalents, by

$$186{\cdot}3\ MK_v=136{\cdot}98\ MK_p=32{\cdot}56\ MK_w.$$

Putting M=46·82 lbs., we find the consumption of heat to be sufficient to raise one pound of water 1524°·5 F., or to convert 1·335 lbs. into steam at 212°, which is adequate to raise 76·880 lbs. one foot, and makes the power of steam to that of air, as 1 : 5·81.

Allowing the steam an equal expansion, the ratio becomes 1 : 4·556.

The relative *theoretic* economy of steam and heated air employed as motive powers is apparently, therefore, not materially affected by varying the ratio of the supply to the working cylinder.

5. *On a Native Boro-titanate;* by Prof. J. LAWRENCE SMITH.*—This interesting compound has been known for some time to American mineralogists, having been first described by Prof. C. U. Shepard, under the name of Warwickite, and considered as a hydrated silico-titanate of magnesia, iron and alumina. It was afterwards described by Mr. T. S. Hunt under the name of Enceladite, and in his last analysis

* This important paper was received at too late an hour to be inserted earlier in this volume.—EDS.

(this Jour., [2] xi, 352,) considered a tri-titanate of magnesia. In the reëxamination of American minerals, in which Mr. Brush and myself are engaged, this mineral came up in turn for examination, and to our amazement, it is found to contain a large amount of boracic acid, doubtless upwards of 20 pr. ct. Approximative analysis are already made, but owing to the difficulty of obtaining it of sufficient quantity in a perfect state of purity, its final examination may be delayed for some time; and it is for that reason thought advisable to publish the present note on the subject. It is essentially a borotitanate of magnesia and iron; the metallic acid, however, has some anomalies about it, not yet cleared up. This is the first borotitanate known, and as such highly interesting, the smallest portion of it, when acted on with sulphuric acid, will give the strongest indication of the presence of boracic acid.

6. *A Supposed Earthquake*, (Northern Journal, Lowville, N. Y., March 16, 1853.)—At Lowville, N. Y., and in its vicinity, early on the morning of Saturday, (between 2 and 3 o'clock,) on the 12th of March, there was a shock like an earthquake. It commenced with a heavy distant rumbling sound, apparently beneath, which gradually increased, and at its maximum broke out in a grand explosion, louder than the loudest thunder. There were other reports, but it diminished, and ended with the same heavy rumbling with which it begun. Houses were shaken so that dishes and furniture were displaced, and the bell of the church struck nine or ten times. The academy bell also rung, although less high. One chimney was thrown down. The people were all aroused and many rushed to the streets. The editors of the paper from which we cite, ask, "Was it an earthquake; or a concussion of the atmosphere, produced by some meteor or aerolite?" and then gives reasons for believing it an actual earthquake, viz: the subterranean character of the sound, the motion of the earth, the absence of any light or flash, and no sudden barometric change.

The direction is stated at from east to west, or the reverse. It was felt at Turin and Copenhagen quite heavy, at Adams heavy, at Watertown slight, at Remsen, Trenton, and Holland Patent not at all. The wind was southeast. The preceding day had been clear, but at 10 in the evening of Friday, the sky became overcast, and unusual darkness prevailed, which continued till the time of the occurrence. The thermometer and barometer gave the following observations:

		Thermometer.	Att. Thermometer.	Barometer.
Friday,	6 A. M.	30·0	45 0	29·252
	2 P. M.	39·5	53·0	29·205
	10 P. M.	27·0	60·0	29·220
Saturd'y	2·30 A. M. time of shock	34·0	52·5	29·140
	6 A. M.	32·5	47·8	29·095
	2 P. M.	40·5	57·0	28·975

7. *Observations on Atmospheric Pressure;* by Lieut. M. F. Maury, (Proc. Acad. Nat. Sci. Philad., vi, p. 313.)—Lieut. M. F. Maury, through Dr. Le Conte, the Corresponding Secretary, presented an engraved diagram, representing a "vertical section of the basin of the Atlantic," about the parallels of 39° and 40° north latitude, the data for which drawing are furnished by the deep sea soundings, taken by officers of the U. S. Navy, in obedience to an order from the Navy

Department. Lieut. Maury says, "These data are not very abundant, but such as they are they give a proximate idea as to the submarine depression."

The diagram exhibits a striking contrast between the profile of the earth's crust above and below the sea level.

The same plate represents a vertical section across the continent of South America from Lima, on the Pacific, to the mouth of the Amazon under the equator, on the Atlantic.

The object of this part of the engraving is to illustrate certain anomalies in the pressure of the atmosphere, as inferred from the experiments of Lieut. Herndon, U. S. Navy, on the boiling point of water, during his recent journey across that section of the continent. The following extract from a table shows the boiling points at several places on the route, and their elevations above the sea respectively:

Heights of Places determined by Lieut. Herndon, U.S.N.

NAMES OF PLACES.	Distance in statute miles from Lima.	Boiling point.	Heights above the level of the sea.
Brought forward, . .	352		
La Cueva, ...	20	206·5	2595 feet.
Lingo Maria, ...	10	207·8	1923 "
Land travel, . . .	382		
Focache, ...	174	209·1	1253 "
Sion, ...	58	209·7	944 "
Lupuna, ...	58	210·	791 "
Chasuta, ...	87	210·5	585 "
Santa Cruz, ...	220	211·2	177 "
Nanta, ...	353	211·3	126 "
Petras, ...	197	211·1	228 "
Egas (904)	707	208·2	1715 "
River Bank, ...	131	208·4	1611 "
"	60	208·5	1560 "
"	168	208·6	1507 "
"	50	208·8	1406 "
Barra, ...	14	209·3	1150 "
Mouth of the Madeira, . . .	104	209·8	893 "
Villa Nova, ...	209	210·3	638 "
Santarem, ...	220	210·5	535 "
Pará, ...	759	211·5	25 "
Sea, ...	93		
Direct water travel, . . .	3652		

A dotted line on the diagram represents Lieut. Herndon's track above the level of the sea, according to the above experiments. "By this track it will be perceived," says Lieut. Maury, "that after ascending the Andes, and coming down the Amazon to a considerable distance, he ascended or went up hill. Now we know that this was not the case, because he was all the time drifting down the stream in a canoe. To reconcile this apparent paradox between the inclination of this slope of the continent, as shown on the one hand by the running water of the rivers, and on the other by the pressure of the air, it is necessary to suppose, that when he boiled his water at the eastern base of the Andes, he was in fact under a bank of atmosphere, and that the pressure under this bank was so great as to force the boiling point up very nearly to the sea level.

Let us now proceed to account as best we may, for this bank, or increased atmospheric pressure.

These experiments were made in south latitude, and in the trade wind region of that hemisphere. These winds strike nearly perpendicularly against the Andes, the tops of which range extend in many places nearly, if not quite as high, as do the trade winds themselves. Now, then, what is the effect of such an obstruction as the Andes afford to the passage of the south east trade winds? If we may judge by the effect of similar obstructions to running water, we have no hesitation in saying that the effect is to bank up.

Pot Rock and other obstructions to the rapid current of Hurlgate—taking small things to represent great—may serve us with an illustration that will assist me in making myself clear. Any one who witnessed the water running over that rock, could not fail to be struck with the fact, and the extent to which the water was piled up, not *over* the rock, but *up stream* from it; not only was there this banking up of the water, before it reached the rock, but there was also a depression *above*—that is, up stream from this bank of water on the one hand, and below or down stream from the rock on the other.

In like manner it appears to me, that Herndon's observations have revealed the fact that there is, at times at least, in the intertropical atmosphere of South America, an air-cast mould of the Andes.

It is remarkable how clearly these observations indicate a piling up of the atmosphere to the windward of the Andes, and a depression in the general atmospheric level to the windward again of this air bank. If this conjecture afford the real explanation of the phenomena, we should look on the lea side of the Andes for a low barometer, or a depression in the atmosphere, corresponding to the hollow in the water below Pot Rock.

The mean height of the barometer in Lima, as far as I have been able to ascertain it, indicates that such a depression is perceived there.

If subsequent observations should confirm these indications and establish them as realities, we should then be put in possession of important physical facts. We should be led to infer that the height of mountains, and of mountain slopes above the sea level, as determined by the barometer, would depend somewhat upon *which way the wind blows*, and the only safe rule of admeasurement in such cases, would be to establish a standard barometer at the foot of the mountains, both on the windward and the lea side.

Another of the physical facts besides that of establishing the direction of the wind, as a function in barometric determination is, that if this increased pressure of the atmosphere at the eastern foot of the Andes be caused by the obstruction which that range of mountains affords to the passage of the trade winds, then do those mountains in the trade wind region become a natural anemometer, which will give us in terms of the barometer an expression for the whole amount of force employed in giving motion and velocity to the trade winds of the earth.

8. *Were the Ancient Egyptians acquainted with Nitric Acid?* by Thornton J. Herapath, Esq., (Lond. Edin. and Dublin Phil. Mag., v, p. 339.)—In the Supplement Number of the Philosophical Magazine for July last, my father published a paper on "Early Egyptian Chem-

istry," in which he gave a short account of some experiments he had made on certain hieroglyphical marks or letters that had been discovered on the wrappers of a mummy which was recently unrolled by Mr. Nash at this Institution; and he then stated it was his belief that the ancient Egyptians were acquainted with a marking fluid containing nitrate of silver for its basis, and were also familiar with the use of nitric acid. A short time afterwards, Mr. Denham Smith, in a reply to this letter, took exception to my father's views on the subject; and whilst admitting the interesting nature of the discovery that had been made of an argentine solution having been employed some three thousand years ago as 'marking ink,' totally dissented from the conclusions that had been founded on it, inasmuch, he said, as there was no evidence to prove that the Egyptians were even acquainted with the art of distillation. He also hazarded the opinion, unsupported, however, by direct evidence, that the marking-fluid in question was prepared—if I understand him aright—by dissolving either the chlorid or oxyd of silver in an ammoniacal solution, and consequently without the intervention of any acid whatever. As the question in dispute is one of considerable interest in a scientific point of view, I determined to subject the marks to a fresh examination. After making several preliminary experiments, I found that no results of any value could be obtained by the ordinary modes of analysis, and was therefore compelled, as a last resource, to call in the assistance of the microscope.

Upon examining some of the fibres of the bandages that were stained by the argentine ink, I found them to present a very peculiar appearance. The ends nearest the corroded parts of the fabric were stained of a deep brown or black; but for some little distance beyond the blackened portion the fibre was colored of a pale yellow hue, as if, during the decomposition of the silver salt that had been employed as 'marking-ink,' nitrogenous constituents of the tissue had been partially acted upon and converted into xanthoproteic acid.

Between several of the fibres, and in many places adhering to their external surfaces, were found small particles of some organic tissue, which were colored of a still deeper yellow than the fibres themselves. On subjecting some of the latter to the action of strong *liquor ammoniæ*, the yellow portions, particularly the altered intercellular substance, acquired a still darker hue, whilst those on the contrary, which were stained by the reduced silver became somewhat paler, as if a portion of the argentine film were soluble in that menstruum; though it should be observed, that no further effect was produced on the stain even by a protracted digestion in ammonia. Now, upon making comparative experiments with a piece of the linen wrapper that had been recently 'marked' in the usual way with a solution of nitrate of silver, the fibres were found to present a very similar appearance to that before described; the only difference being that the yellow coloration was not quite so distinct, and more of the silver stain was removed by the solution of ammonia; whereas, on the other hand, fibres that had been stained by solutions of chlorid and oxyd of silver in ammonia were uniformly colored of a dark brown or black, and exhibited no trace of yellow coloration.

These results, conjoined with the corroded state of the linen in the vicinity of the marks, justify us, I think, in concluding that the ancient Egyptians were really acquainted with nitric acid; and, as my father has already suggested, employed the nitrate of silver as a marking-fluid. In what manner, however, they prepared the acid, whether by the distillation of the nitrate of soda or nitrate of potash with oil of vitriol, or by one of the processes adopted by the alchemists, I will not at present attempt to decide, but will leave the problem to be solved at some future period, when the researches of antiquarians shall have offered us further evidence on the subject.

9. *California Academy of Natural Sciences.*—An Academy of Natural Science has recently been instituted at San Francisco, California, having for its objects the collection of specimens in various departments of science, and lectures and publications on scientific subjects. A Randall, Esq., has been elected President, H. Gibbons and T. J. Nevins, Vice Presidents, W. P. Gibbons, Corresponding Secretary, L. W. Sloat, Recording Secretary, A. B. Stout, Treasurer.

10. *Aurora seen at Perryville, on the 24th of May*, 1853; by Prof. G. W. Wheeler.—At a quarter before nine, P. M., May 24th, a bank of white light lay along the northern horizon, elevated perhaps 10° due north, and extending about 100° on the horizon.

Nine o'clock, streamers distinctly visible in the N. W., and a little to the E. of N.

9¼, Streamers more visible; bank less so. Some of the streamers could be traced above the pole star.

9½, Streamers not so high, but occupy almost the whole bank.

9¾, Streamers hardly perceptible; bank disappearing.

10, Bank and streamers have both disappeared

The light was white and slightly yellow, nothing of redness; the evening clear and still; thermometer 13° Cent. Perryville is in Lat. 37° 43′ 56″, Long. 89° 53′ 20″.

11. *The Great Gold Nugget*, (Athenæum, No. 1344.)—The *Times* states, that the great Australian nugget lately exhibited at Mr. Wyld's Globe, in Liecester Square, has been melted and sold by Messrs. Haggard and Pixley, bullion brokers, for 5,532*l*. Its weight before melting was 1,615 ounces; and it yielded 1,319 ounces of fine gold, equal to 1,423 ounces standard.

12. *Polytechnic College, Philadelphia.*—A Polytechnic College has been chartered by the State of Pennsylvania, to be established in the city of Philadelphia. Mining and Metallurgy, Agriculture, Manufactures, Mathematics, and Engineering, are to be its main branches of instruction. A chemical laboratory, mineralogical collections, and other appurtenances required for instruction in the practical applications of science, are included in the plan. The professorship of Metallurgy, and Industrial, Agricultural, and Analytical Chemistry, (a large range for one man,) is stated to be filled, but the three other departments proposed are yet to be provided with Professors.

13. *Notice to Naturalists.*—The Cabinet of the late Dexter Marsh will be offered at public auction, on Wednesday, the twenty-first day of September next. It embraces a great variety of natural objects; but its peculiar value consists in its unrivalled collection of Fossil Footprints of

Birds and Quadrupeds, and the Impressions of Fishes, from the new red sandstone of the Connecticut River. The collection of Minerals embraces an immense number of Crystals of Beryl, some of vast size, from the celebrated locality of Acworth, N. H. Particulars will be sent upon application to the subscriber. Among the specimens of this collection are the following, appraised by President Hitchcock, and Dr. Deane:

Ornithichnites.—No. 92. A Slab, 10×6 feet, literally covered with Footprints of Birds, at least 70 distinct impressions, arranged in determinate lines or transits. In two of these transits the Footstep is 10 inches in length, and the stride 3 feet and 8 inches. The surface is very bright and smooth, and the impressions are without blemish, showing in the most distinct manner the phalangeal, tarsal, and ungual depressions of the foot. Appraised at $350.

No. 93. Is the counterpart or cast of the foregoing, very fine. Appraised at $150.

No. 94. A slab in two pieces, about 8×4 feet in dimensions, from the same stratum as No. 92. 17 fine impressions, Appraised at $75.

No. 96. About 5×3 feet. 9 rows of tracks on its superior surface, and several in relief on its inferior. The impressions are very fine. The specimen is mounted to take a revolving motion. Appraised at $150.

No. 95. About 7×4. Literally covered with perfect impressions, at least 40 in all, arranged in determinate lines. Appraised at $75.

No. 97. Two Colossal Footprints, each 16 inches in length; stride 3 feet 6 inches. Very fine. Appraised at $25.

No. 100. Two Colossal Footprints, each 14 inches long; stride 3 feet 4 inches. Appraised at $25.

No. 99. A slab 6 feet 4 inches in length. One row of consecutive footprints, and others, very fine. Appraised at $30.

No. 98. Slab 7 feet 6 inches long. Footprints and Raindrops in relief. Appraised at $20.

No. 101. Four splendid impressions. Appraised at $20.

No. 102. Six imprints. Appraised at $10.

No. 103. A single Colossal Footprint, 18 inches in length. Appraised at $25.

Besides the foregoing, are a very great number of specimens, 100 of which are enumerated, appraised from $10 to $1. They are mostly from the celebrated localities of Turner's Falls, and South Hadley Falls, and embrace a large number of species; and the individual impressions are all so perfect as to display the anatomical configurations and phalangeal markings of the foot. It is a magnificent collection. These specimens will be sold singly, or in lots, as may be desired, to the highest bidder, starting from the appraised value.

Quadrupedal Footprints.—The Footprints of Quadrupeds are quite rare in the Sandstone Formation, yet they are very interesting. The collection embraces all the known species, and the specimens are truly beautiful. They indicate animals of diminutive size, probably of the Batrachian order of Reptiles, or the Tailed or Salamandrian species. The slabs containing these footprints are small, and are appraised from $10 downward.

Ichthyolites, or Fossil Fishes.—The collection of American Fossil Fishes is very extensive, and is derived from the localities of Sunderland, Mass., Middletown, Conn., and Pompton, N. J., and embraces eight or ten species of the Genera Paleoniscus and Catopterus. The specimens enumerated, amounting to 200, are entire and remarkably fine, and are appraised at $25, $20, $15, $10, $5, down to $1. Taken altogether, this collection offers a rare opportunity for acquiring these elegant fossils, which are otherwise so difficult to obtain, especially in a sound condition.

Minerals.—The collection of Beryls from Acworth, N. H., is large, and was obtained by Mr. Marsh, as were the foregoing fossils, by his personal exertions, and at great expense. It is very valuable, and was appraised by Prof. C. U. Shepard and Dr. Edward Hitchcock, and among the principal specimens are the following:

				Apprais'd at
No. 240.	11 in. diam.	38 in. circum.	12 in. length.	$20.
No. 235.	8 " "	26 " "	24 " " "	$15.
No. 234.	7½ " "	24 " "	9 " " "	$10.
No. 239.	9 " "	32 " "	19 " " "	$10.
No. 237.	9 " "	29 " "	14 " " "	$3.
No. 253.	15 " "	39 " "	16 " " "	$15.
No. 255.	12 " "	40 " "	10 " " "	$4.
No. 251.	8 " "	28 " "	13 " " "	$4.
No. 265.	13 " "	" "	12 " " "	$6.
No. 274.	9 " "	30 " "	22 " " "	$7.
No. 279.	12 " "	38 " "	13 " " "	$8.

Besides many others at $10, $8, $5, $3, $1, of which more than 100 specimens are enumerated. They are also arranged into suites, and will supply very desirable collections for mineralogists.

There are other choice minerals; among them are various specimens of Fossil Woods; of Dog Tooth Spar; of Fluor Spar; Galena; Barytes; Hematite; Specular Iron Ore; Calcite; Celestine; Troostite; Malachite; Tremolite; Lead and Silver ores; Tin Ore. A large number of Quartz Crystals, some containing water and other objects, and a great number of other specimens, Geodes, Septaria, Rain Drops, &c.

Miscellaneous Objects—Illustrating Aboriginal Arts. 225 specimens Indian Relics, found in the Valley of Connecticut River.

Eleven pieces Pottery and Discoidal Stones from the Mounds of Mississippi, very interesting. Stuffed Birds, Alligator, Boa Skins, Roman Lamp, Ancient Mosaic, English Minerals and Fossils, Limestone and Chalk Fossils, Coal Fossils, Mastodon remains, Fossil Corals, Show Cases, &c.

Coins.—1118 Pieces Copper Coins, including duplicates. 85 very rare Coins and Medals.

Shells.—A valuable collection of Shells and Corals.

Valuable Books.—17 Quarto Volumes Geological Survey of New York, Owen's Geological Survey, Hitchcock's Geology of Massachusetts, &c.

☞ The sale will be continued from day to day until it is completed, and it will probably afford the only opportunity that will occur for a long time, if ever, of acquiring the beautiful fossils of Connecticut River.

They can only be obtained by skillful prospecting at great risk and expense. All the localities have been exhausted for several years, and the only source from which they can now possibly be obtained is this extraordinary cabinet. The collection of these fossils is so extensive that several complete suites can be formed from it; for beauty, extent, and interest, it far surpasses any other collection ever made, in fact, all other collections combined ever made. L. MERRIAM, *Administrator.*

Greenfield, Mass., July, 1853.

V. BIBLIOGRAPHY.

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2. *Report on certain points in the Geology of Massachusetts;* by Pres. EDWARD HITCHCOCK. Exec. Dep't Mass.; House Doc. No. 39. —This valuable report treats of (1.) the Coal Field of Bristol county and of Rhode Island; (2.) the Determination of the geological age and position of the beds of Brown Hematite Iron Ore in Berkshire county, Mass.; (3.) Marks of ancient Glaciers in Massachusetts. The second section has already appeared in this Journal; the others we propose to cite from at length in our next.

3. *Physical Geography;* by MARY SOMERVILLE, author of the connection of the "Physical Sciences," Mechanism of the Heavens, etc. A new American, from the 3d and revised London edition; with notes and a glossary, by W. S. W. RUSCHENBERGER, M.D., U. S. Navy. 570 pp. 12mo. Philadelphia, 1853. Blanchard and Lea.—The Physical Geography of Mrs. Somerville, the most learned woman of the age, is already well known. The whole range of the earth's physical features, both inorganic and organic, superficial, subterranean, and atmospheric, comes under discussion, beginning with a brief review of the principles of Geological Science, and closing with the races of mankind, their arts and civilization. This edition is somewhat enlarged through contributions to the work, by Dr. Ruschenberger, the American editor.

4. *Catalogue of the Oological Collection in the Academy of Natural Sciences of Philadelyhia;* by A. L. HEERMANN, M.D., March 1, 1853.—This catalogue of birds' eggs embraces 1323 determined species of 493 genera. Of these, 835 species, derived from all parts of the world, formed the celebrated and valuable collection of Mons. O. Des Murs, of Paris. The Australian species, numbering 246, accompanied the splendid collection of birds from that country, made by the distinguished ornithologist Mr. John Gould, of London, and which is now in the Museum of the Academy. The Cuba species belonged to the collection of the well known naturalist M. Ramon de la Sagra, and were presented by Mr. E. Wilson.

The whole of the first two collections were purchased by Dr. T. B. Wilson, and, with his usual liberality, presented to the Academy. The remainder consists of species presented by several individuals whose names are attached to their donations throughout the catalogue. Of undetermined eggs in the collections of M. Des Murs and Mr. Gould, there are 197 species.

5. *Rural Essays;* by A. J. Downing, edited, with a memoir of the author, by George William Curtis, and a letter to his friends by Frederika Bremer. G. P. Putnam and Co.: New York, 1853. 558 pp. 8vo.—The Rural Essays here issued originally appeared as editorials in the Horticulturist. We are gratified to see them collected together under the elegant form now given them by Putnam. No one has done more by his writings or taste for American Landscape Gardening and Horticulture than Mr. Downing, and his death was one of the great calamities of the last year. The memoir of Mr. Downing by Mr. Curtis is full of interest, and forms a most appropriate introduction to the volume.

6. *Sixty-Sixth Annual Report of the Regents of the University of the State of New York.* 316 pp. 8vo. Albany, 1853.—Following the details relating to the public schools of New York, this Report contains several valuable Meteorological Tables; Observations on the Weather, Auroras, Level of the Lakes, Productiveness, etc., of 1852, Flowering of Plants, &c., by Rev. Chester Dewey; Table of the Periods when the Hudson River opened and closed at Albany; Tables of the Fall of Rain in the State; on the Periods of Cold Weather during the last few years, and the connection of Earthquakes with Atmospheric Changes, by E. Merriam.

7. *Illustrated Record of the Industry of all Nations;* Nos. 1, 2, 3, 4. Edited by B. Silliman, Jr. New York: G. P. Putnam and Co. Double Numbers of 18 pp. 4to, 25 cents.—This Illustrated Record, is as the name implies, a descriptive record of the objects of interest exhibited at the Crystal Palace, illustrated by engravings. The engravings are in wood, and are handsomely executed. The numbers in 4to, are printed in the best style, on a press at the Crystal Palace itself. The elegance of this publication, its cheapness, and its intrinsic value will insure it a wide distribution over the land. The display at the Palace is full of attractions in all the departments of the arts. It is inferior in extent to the Exhibition at London, but it should be observed, that while the one was the work of the British Empire, with the wealth of the nation at command, and enjoyed from the first the full confidence of the civilized world, near the centre of which it was placed, the other is in fact a private enterprise, in the western hemisphere, honored by the Government only after its completion, and till recently gaining but slowly the confidence of the people among whom it has been erected.

8. *The Mining Magazine.* No. II. August, 1853. Edited by Wm. J. Tenney, New York City, 142 Fulton St.—A good mining Journal, which should be a faithful and impartial record of mines and mining, would have a wide circulation through the land, where now there is an increasing interest in the mineral resources of this and other countries. The magazine before us, if ably conducted, would meet this want. We judge however, from the paper on the mines and mineral resources

of America, (No. II,) that more care will be needed in the preparation of papers, before it will reach the standard it should assume. In mentioning the mineral productions of New York, distinction is seldom made between good and bad localities, and an erroneous idea is conveyed of the productiveness of the State in metals. The artificial oxyd of zinc of the New Jersey furnaces correctly described in this Journal by Dr. Torrey, as early as 1822, (vol. v,) and more recently by Mr. Blake, the past year, (vol. xiii, 2nd. Ser., 417,) is spoken of first as the ancramitic oxyd of zinc, and afterwards under the old incorrect name of *Cadmia*, which is attributed to Prof. Silliman. The name ancramite was given it when it was first noticed, but has long since dropped out of use. Certain New York localities of zinc ore are stated to yield sulphate of zinc, *chromate* and carbonate. The precious stones of New York mentioned are, jasper, agate, garnets, *emerald*. The article on the Mines and Mineral Resources of America, (No. II,) thus leads the reader to believe that many things occur in the state of New York which do not, and that many localities afford workable beds, where there are mere traces of ore.

9. *Memphis Medical Recorder*, published bi-monthly by the Memphis Medical College. Edited by A. P. MERRILL, M.D., Prof. Mat. Med. and Therap., and C. T. QUINTARD, M.D., Prof. Phys. and Path. Anat. 48 pp. 8vo. Memphis. Vol. ii, No. 1, July, 1853. $1 per annum.—The western medical journals have a special value in the knowledge they are able to give of the diseases of the Mississippi Valley, and of the uses of medicines in their treatment. We understand that Prof. J. Millington is to be connected with the Memphis Medical College, and will contribute to the Memphis Medical Recorder. The present number contains as original papers, one on the uses of Veratrum viride, by H. V. Wooten, M.D., another on the relations of uterine and constitutional disorders as cause and effect, by L. Shanks, M.D.

10. *Annals of Science*, conducted by HAMILTON L. SMITH, A.M. Cleveland. The number of this semi-monthly for April 1, contains an important paper on fossil plants from Ohio, by J. W. FOSTER, illustrated by wood-cuts; and the numbers for February, March, April 15 and May, others on the same subject, by J. S. NEWBERRY.

11. *Report of the Superintendent of the Census for December*, 1852, *to which is appended the Report of December* 1, 1853. Printed by order of the House of Representatives of the United States. Washington, 1853.

12. Transactions of the Meteorological Society of Mauritius. 1853. No. 1, 8vo. 124 pp.

13. *Annals of the Lyceum of Natural History of New York, May*, 1853. Vol. vi, No. 1.—(1.) Descriptions of new species of birds of the genera *Ortyx*, Stephens, *Sterna*, Lin., *Icteria*, Vieillot, by G. N. LAWRENCE.—p. 1.

(2.) Additions to North American Ornithology, No. 3, by G. N. LAWRENCE.—p. 4, No. 2.

(3.) Ornithological Notes, by G. N. LAWRENCE.—p. 7.

(4.) Descriptions of new species of Helicidæ, by J. H. REDFIELD.—p. 14.

(5.) Descriptions of new species of Achatinella, from the Sandwich Islands, by Dr. W. NEWCOMB.—p. 18.

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(6.) Note to the Description of Selene argentea of Lacepede, in vol. v of the Annals, by J. C. BREVOORT.—p. 30.

(7.) Observations on the animal of *Rotella*, Lam., by Rev. S. C. FAIRBANK, of Bombay.—p. 35.

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Dr. FRIEDRICH PFAFF: Grundriss der mathematischen Verhaltnisse der Krystalle. 368 pp., 8vo, with 16 plates. *Nördlingen*, 1853.

C. F. PLATTNER: Die Probirkunst mit dem Löthrohre. 3d. Edit. 716 pp. 8vo. *Leipzig*, 1853.

FRANZ VON KOBELL: Die Mineral-namen und die mineralogische Nomenklatur. 160 pp., 8vo. *München*, 1853.—An important work giving the origin of the names of minerals, with criticisms and rules relating to mineralogical nomenclature. We observe a few errors respecting American minerals. *Edwardsite* is said to be named after Governor Edwards of *South Carolina;* it should be *of Connecticut*;—Franklinite, after Benjamin Franklin; correctly it was after the locality near Franklin Furnace, N. J.;—Pennite, after Penna, in North America, instead of Pennsylvania. Shephard's name *Eremite*, is wrongly attributed to Dana. Jacksonite is incorrectly spelt without *c* and with an *e* after the *k*; and the name of Dr. Jackson is written Dr. Ch. Jackson, instead of Dr. Ch. T. Jackson. Among the rules which von Kobell lays down and strongly insists upon is the spelling of foreign names derived from names of persons, as they are spelt in the country from which they are taken.—Under Johnstonite, it is stated that it is named after the *North American* Mineralogist and Chemist, J. F. W. Johnston; it should be the *English*, &c. The name of J. Lawrence Smith, is written without the J.

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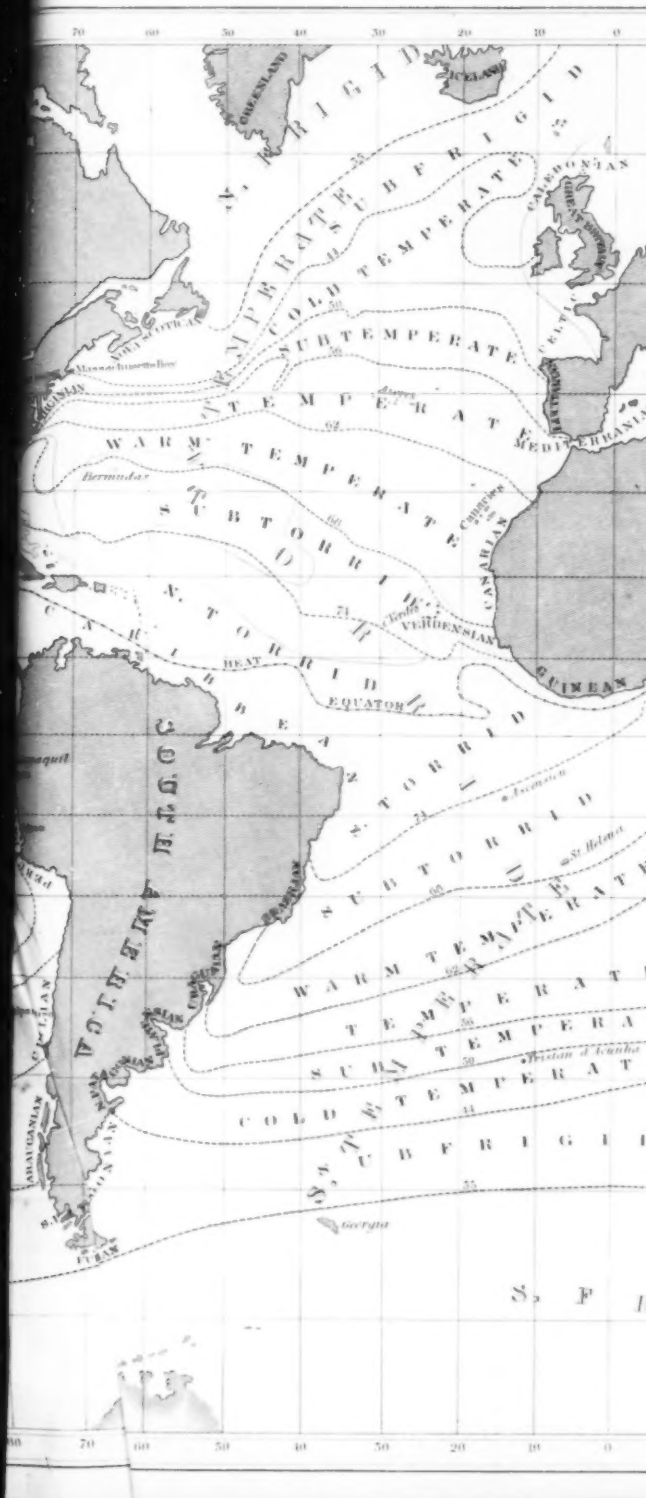
PROCEEDINGS OF THE BOSTON SOCIETY OF NAT. HIST.—p. 295. Notes on the extraction of the iron from the Franklinite of New Jersey; *C. T. Jackson*.—p. 297. On the probable depth of the ocean of the European chalk deposits in opposition to the view of Prof. E. Forbes, that it was a deep ocean; *H. D. Rogers*.—p. 298. On a bone of Palapteryx; *Dr. Kneeland*.—p. 300. On an Earthquake at Manilla, Sept. 16, 1852; Dr. Kneeland.—p. 303. On the sandhill crane; *Dr. Bryant*.

PROCEEDINGS OF THE ACAD. NAT. SCI. PHILAD., vol. vi, No. 9.—p. 326.—Note on pearls made by putting small images of lead in the shell of Dipsas plicatus; *Major Le Conte*.—On the genus Talpa, and the identity of Scalops with it; *J. L. Le Conte*.—p. 328. Synopsis of the Meloides of the United States; *J. L. Le Conte*.—p. 350. Synopsis of the Atopidæ, Rhipiceridæ, and Cyphonidæ of the U. S.; *J. L. Le Conte*.—p. 357. Synopsis of the Endomychidæ of the U. S.; *J. L. Le Conte*.—p. 361. Descriptions of some new species of insects, with observations on described species; *S. S. Haldeman*.—p. 365. Description of new Nemerteans and Planarians from the coast of the Carolinas; *C. Girard*.—p. 368. Notice of the Mya nodulosa, Wood; *J. Lea*.—p. 368. Descriptions of some new Fishes from the River Zuni; *S. F. Baird & C. Girard*.—p. 369. Descriptions of new species of Hirundinidæ and Psittacidæ, specimens of which are in the collection of the Academy; *John Cassin*.—Catalogue of the Hirundinidæ, in the collection of the Academy; *John Cassin*.


N. FRIGID
ICELAND
GREENLAND
N. TEMPERATE SUBFRIGID
COLD SUBTEMPERATE
CALEDONIAN
SUBTEMPERATE
WARM TEMPERATE
MEDITERRANEAN
Bermudas
SUBTORRID
CANARIAN
Cape Verd Is.
VERDENSIAN
GUINEAN
N. TORRID
HEAT
EQUATOR
S. TORRID
Ascension
St Helena
SUBTORRID
WARM TEMPERATE
TEMPERATE
SUBTEMPERATE
Meridian of Greenwich
COLD TEMPERATE
S. SUBFRIGID
Georgia
S. F
ATLANTIC OCEAN
PERUVIAN
CHILIAN
ARAUCANIAN
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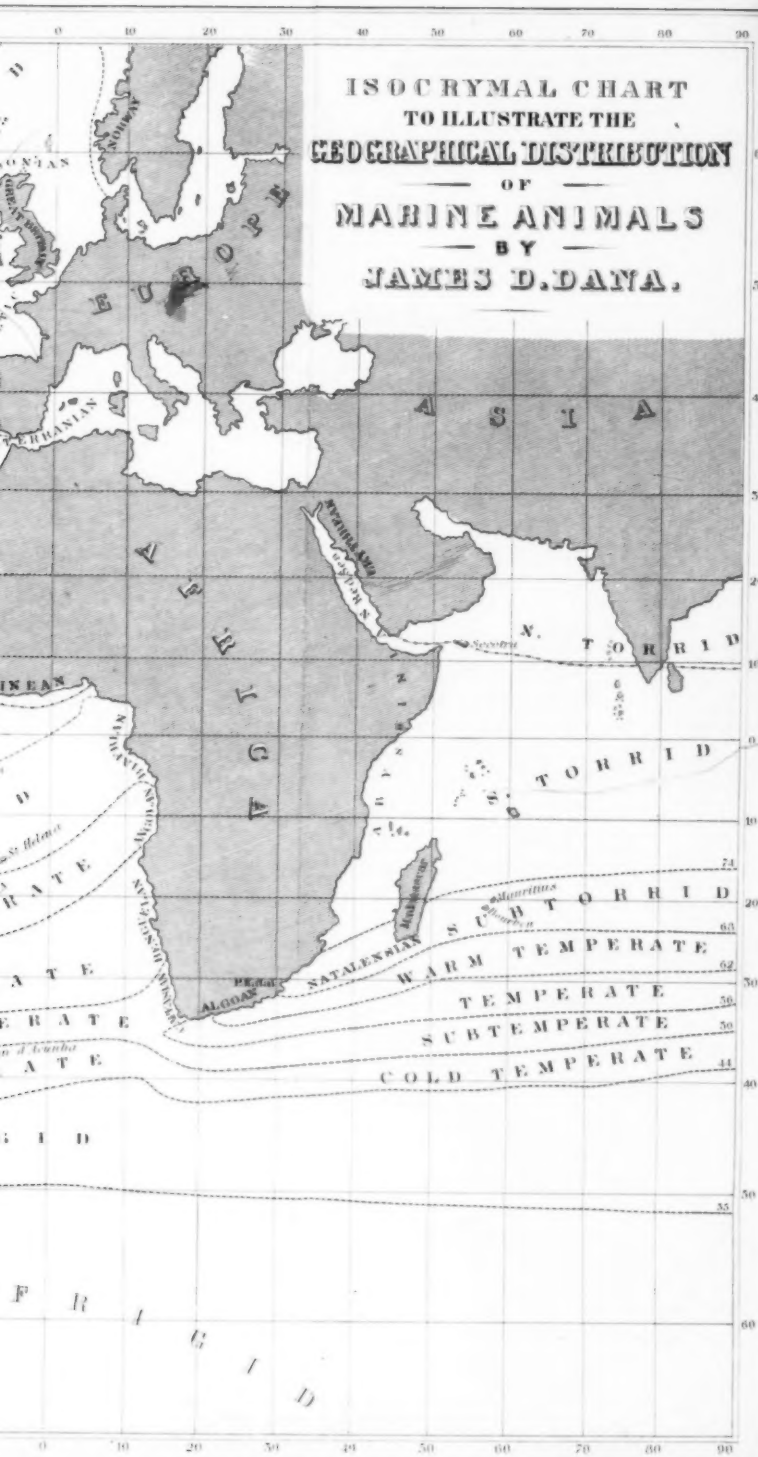
ISOCRYMAL CHART
TO ILLUSTRATE THE
GEOGRAPHICAL DISTRIBUTION
OF
MARINE ANIMALS
BY
JAMES D. DANA.
EUROPE
ASIA
AFRICA
N. TORRID
S. TORRID
SUBTORRID
WARM TEMPERATE
TEMPERATE
SUBTEMPERATE
COLD TEMPERATE
ALGOA
NATALENSIAN
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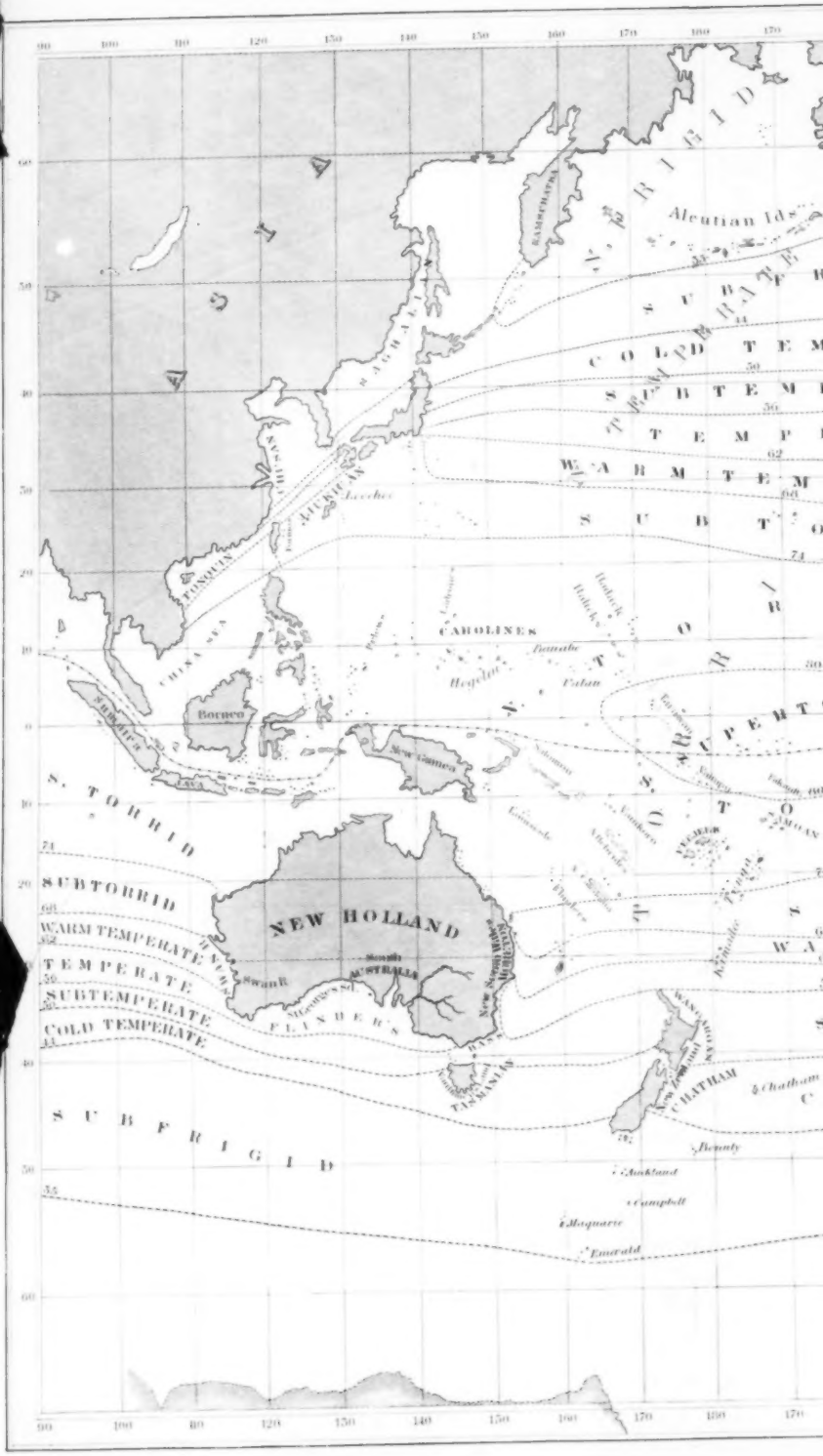
Aleutian Ids
CAROLINES
Borneo
Sumatra
New Guinea
NEW HOLLAND
South AUSTRALIA
Swan R.
Macquarie
Auckland
Campbell
Chatham
Bounty
Emerald
SUBTORRID
WARM TEMPERATE
TEMPERATE
SUBTEMPERATE
COLD TEMPERATE
SUBFRIGID
FRIGID
TORRID
CHINA SEA
FLINDER'S

NORTH AMERICA
FRIGID
TEMPERATE
TEMPERATE
TEMPERATE
TEMPERATE
TORRID
TORRID
TORRID
SUBTORRID
WARM TEMPERATE
WARM TEMPERATE
SUBTEMPERATE
COLD TEMPERATE
SUBFRIGID
FRIGID
HEAT EQUATOR
San Francisco
Columbia
Sandwich Islands
Marquesas
Tahiti
Easter
Chatham I.
170
160
150
140
130
120
110